STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN DISTRICT

BULLETIN NO. 104

PLANNED UTILIZATION OF THE GROUND WATER BASINS OF THE COASTAL PLAIN OF LOS ANGELES COUNTY

APPENDIX A
GROUND WATER GEOLOGY

EDMUND G. BROWN
Governor

WILLIAM E. WARNE
Director

JUNE 1961

FOREWORD

At present more than half of the water supply of the South Coastal Area of Southern California is furnished by water from the ground water basins of the area. In general, the drafts on the ground water basins exceed the supply thereto, resulting in overdraft conditions that are expressed by the alarming decline of ground water levels. The lowered ground water levels result in higher costs of pumping, increased problems of maintaining proper salt balance, and in some basins, sea water or connate brine intrusion which threatens destruction of the utilization of the ground water basin.

The serious nature of this continuing and increasing overdraft of the ground water supply led many local water agencies and water users associations to request that detailed information on geology, hydrology, and basin operation be provided to assist them in overcoming or at least alleviating this dangerous condition. As a result of these requests, many by way of formal resolutions, the Southern District of the Department of Water Resources formulated a comprehensive program for an investigation of the planned utilization of the major ground water basins of Southern California.

The general objective of the basic program is to formulate a coordinated plan of operation that will permit the maximum utilization of these ground water basins in conserving the local water supply and in storing and distributing imported water. To attain this objective the work program for each basin investigation is divided into three phases: geology, hydrology, and operation and management. The first two phases provide the basic information required to develop a plan for coordinated ground water basin operation and will be detailed in interim reports as the studies are completed in each ground water basin. The final report on the planned utilization of each ground water basin will summarize the information contained in the interim reports and present and compare the alternative plans for coordinated operation of the ground water basin.

The Legislature provided funds during the 1959 General Session to initiate this program. The first ground water basins to be investigated underlie the Coastal Plain of Los Angeles County. The first phase of this investigation, the geologic study, has been completed and is presented in detail in this report.

TABLE OF CONTENTS

TABLES

PLATES

ATTACHMENTS
(Bound at end of report)

EDMUND G. BROWN
GOVERNOR

WILLIAM E. WARNE
DIRECTOR

ADDRESS REPLY TO
P. O. BOX 388 SACRAMENTO
1120 N STREET HICKORY 5-

STATE OF CALIFORNIA
Department of Water Resources
SACRAMENTO

June 14, 1961

The Honorable Edmund G. Brown, Governor, and
Members of the Legislature of the
State of California

Gentlemen:

I have the honor to transmit herewith Appendix A, "Ground Water Geology", a portion of Bulletin No. 104, entitled "Planned Utilization of the Ground Water Basins of the Coastal Plain of Los Angeles County".

This appendix presents data and conclusions on the extent, thickness, and lithology of the aquifers comprising the ground water basins of the Coastal Plain of Los Angeles County. It also describes the connections between the different aquifers, the areas where recharge to the aquifers are possible from the ground surface, and the effects of structural features on the movement of water through the basins. Geologic studies of this nature are required for proper operation of the ground water basins and for adequate planning and design of facilities for utilization of imported water.

Sincerely yours,

William E. Warne

Director

ACKNOWLEDGMENTS

Valuable assistance and data used in this investigation were contributed by agencies of the Federal Government and of the State of California, by cities, counties, public districts, and by private companies and individuals. This cooperation is gratefully acknowledged.

Special mention is made of the helpful cooperation of the following:

California Department of Public Works, Division of Highways

California Department of Natural Resources, Division of Mines and Division of Oil and Gas

Long Beach State College

Los Angeles County Engineers Office, Water Works Districts

Los Angeles County Flood Control District

Los Angeles Museum of History, Science, and Art; especially Theodore Downs, Curator of Vertebrate Paleontology and George P. Kanakoff, Curator of Invertebrate Paleontology

Richfield Oil Corporation

San Gabriel Valley Protective Association

Signal Oil and Gas Company

Standard Oil Company of California

Southwest Museum; especially Ruth D. Simpson, Assistant Curator

Texaco, Inc.

The Associated Colleges of Claremont

The California Institute of Technology

The University of California at Los Angeles, and at Riverside

The University of Southern California

United States Geological Survey, Ground Water Branch, Long Beach

Western Gulf Oil Company

STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES

Edmund G. Brown, Governor

William E. Warne, Director of Water Resources

SOUTHERN DISTRICT

John R. Teerink . . . . District Manager

The investigation leading to this report
was conducted under the direction
of

Lloyd C. Fowler . . . . Chief, Planning Branch

by

Robert G. Thomas . . . . Senior Engineering Geologist
John J. Landry . . . . Associate Engineering Geologist
Robert J. Turney . . . . Assistant Engineering Geologist

Assisted by

John R. Cummings . . . . Assistant Engineering Geologist
Joseph F. LoBue . . . . Junior Engineering Geologist
John T. Scheliga . . . . Junior Engineering Geologist
Ernest H. Gilmour . . . . Junior Engineering Geologist

Staff review was provided
by

Laurence B. James . . . . Chief Geologist

CHAPTER I. INTRODUCTION

This report describes the geology of the water-bearing sediments and formations of the Coastal Plain of Los Angeles County, California. The information it contains will be used to support studies of the hydrology, water quality, and operational characteristics of the ground water basins in the area. The material presented includes a description of the geologic history of the area, the composition and extent of the aquifers of the coastal plain, the areas where recharge to the aquifers from the ground surface could occur, the geologic structure affecting the occurrence and movement of ground water through the area, and finally, a description of the individual ground water basins which comprise the coastal plain.

Description of Area

The area covered in this report is shown on Plate 1, entitled "General Geology and Location of Area of Investigation". In Los Angeles and Orange Counties there is a large coastal plain which extends inland from the Pacific Ocean. The ground water basins underlying this coastal plain are complex and the area is large; therefore, in order to adequately meet the objectives of this investigation within a reasonable period of time, the area was somewhat arbitrarily divided along the Los Angeles-Orange County line. This report considers only the northern portion of the coastal plain, that within Los Angeles County. The geology of the southern portion of the coastal plain within Orange County will be developed and reported upon subsequently.

The area of investigation is then the Coastal Plain of Los Angeles County. It is bounded by the Santa Monica Mountains on the north, the low-lying Elysian, Repetto, Merced, and Puente Hills on the northeast, the

Los Angeles-Orange County line on the southeast, and the Pacific Ocean on the south and west. This 480 square mile portion of the coastal plain slopes gently from the bordering highlands on the north and northeast toward the ocean. The locations of these features are shown on Plate 2, entitled "Physiographic Features and Ground Water Basins".

Three main stream channels, the Los Angeles River, San Gabriel River, and Rio Hondo flow into the area from the interior valleys. The Los Angeles River drains the San Fernando Valley and flows southward across the coastal plain to discharge into the Pacific Ocean at San Pedro Bay. The San Gabriel River and Rio Hondo drain the San Gabriel Valley. The Rio Hondo flows southwesterly across the coastal plain and joines the Los Angeles River about midway in its journey across the coastal plain. The San Gabriel River flows southerly across the coastal plain and discharges into the Pacific Ocean about six miles southeast of the mouth of the Los Angeles River.

Authorization for Investigation

The Legislature, by Chapter 832, Statutes of 1929, directed that exploration and investigation be conducted to further a coordinated plan for the conservation, development, and utilization of the water resources of California. As a result of this legislation and pursuant to authorization contained in Sections 225 and 226 of the Water Code, a continuing hydrologic investigation of the Southern California area has been carried on. The work generally included, among other specific objectives, compilation of hydrologic data for use in a full scale investigation when needed and feasible.

Limited work on the investigation of the geology of the Coastal Plain of Los Angeles County was initiated in 1955 and carried on to the extent funds were available in the following years. During the 1959 session of the Legislature, responsible local agencies in Los Angeles County were instrumental in obtaining a $150,000 augmentation of the Department's 1959-60 budget to finance an intensive investigation of the ground water basins of Southern California. With these funds, it has been possible to finish this study of the geology of the area and concurrently carry forward hydrologic and operational studies which will lead to completion of plans for operation of the ground water complex underlying coastal Los Angeles County.

Previous Investigations

Because of the coordinated efforts of both oil company and academic geologists to unravel the complex structures involved in the oil fields within the Coastal Plain of Los Angeles County, the geologic history of the deeper and older consolidated sediments is better known than that of the shallower water-bearing materials. The younger shallower sediments have been studied where interest in ground water occurrence and movement has developed. Publications reporting those studies utilized in this investigation are listed in the bibliography.

W. C. Mendenhall of the United States Geological Survey first made a broad survey of wells and geology in the Upper Santa Ana Valley and the coastal plain in 1905. As ground water problems became apparent, interest in the younger alluvial deposits gained impetus and further geologic investigations were conducted.

In 1934, Bulletin No. 45, "South Coastal Basin Investigation, Geology and Ground Water Storage Capacity of Valley Fill", was published by the California Department of Public Works, Division of Water Resources. The fragmentary geologic work, both published and unpublished, which existed up to that time was reviewed, and original field and laboratory studies of the water-bearing sediments of the area were made.

After publication of Bulletin No. 45, relatively little work was accomplished on the water-bearing materials until the United States Geological Survey began an investigation which culminated in a series of open-file reports in the 1945-48 period. Some of these reports have been published in recent years. Both the published and unpublished Geological Survey reports are listed in the bibliography.

A report was prepared on an investigation of the West Coast Basin by the California Division of Water Resources, acting as Referee that was entitled "Report of Referee, California Water Service Company versus City of Compton, et al . . .", included considerable detailed geologic work in the West Coast Basin. This work was adopted, with minor modifications, for the purposes of this investigation.

Bulletin No. 170, "Geology of Southern California", published in 1954 by the California Department of Natural Resources, Division of Mines, contains many maps and articles on the geology of the coastal plain. One of the geologic contributions included in this bulletin is the "Geology of the Los Angeles Basin", by A. O. Woodford, J. E. Schoellhamer, J. G. Vedder, and R. F. Yerkes.

Scope of Report

The studies leading to this report began in 1955. At that time, it was planned to investigate only the area in and near Whittier Narrows. Field location of wells, both new and old, began in 1955 and continued sporadically in 1956. Interest in the geology of the coastal plain increased as the formation of the Central and West Basin Water Replenishment District was discussed and initiated. By 1957 it had become apparent that geologic studies would have to include a larger portion of the coastal plain than was originally planned, in order to make the geologic picture complete. Consequently, the geologic studies have included all of the Coastal Plain of Los Angeles County, with particular emphasis on the Central Basin.

Previous detailed data accumulated for the West Coast Basin reference study was utilized to the maximum extent. In addition, about 200 drillers logs and electric logs of oil wells, 3,500 water well drillers logs, and 20 electric logs of water wells were used in this study. Additional information was obtained from records of test holes and seismic work of various agencies and companies. The results of over 40 transmissibility tests made during this study and during the West Coast Basin reference study were used. (See Table C, Attachment 2). Outcrops of important water-bearing formations were visited in the field and descriptions of temporary excavations visited by department personnel were carefully studied. Paleontological data were used where possible to aid in correlation of subsurface strata. In all areas, ground water levels and water quality data were used to the extent available in checking the validity of these correlations.

Approximately 50 geologic sections were compiled from the logs of water and oil wells. Fifteen of these are shown on plates included with this report. The cross sections are oriented in north-south and east-west directions, since this follows the prevailing highway net and more wells are found adjacent to major thoroughfares. This also made it convenient to form a grid in order to trace aquifers across the coastal plain. Wells were used wherever possible for matching the cross sections at the points of intersection.

This report contains six chapters in addition to this introduction. Chapter II, "Geologic History", relates the succession of geologic events for which evidence is present in the area of investigation. The chapter begins with the oldest known events and ends with Recent and presently active events. The third chapter, "Physiography", describes the land forms of the area of investigation. These land forms, or physiographic features, are the result of erosion combined with such transporting agents as water, gravity, and wind acting over a long period of time upon the sediments and rocks comprising the surface of the area. The present drainage system and the water-bearing quality of the physiographic features are discussed in this chapter.

Chapter IV, "Stratigraphy", describes the sediments and rocks now present in the coastal plain and the aquifers and aquicludes that have been identified in these sediments. The lithology of the more permeable Recent and Pleistocene sediments is discussed from the surface downward in some detail. The older underlying sediments and rocks, which are generally nonwater-bearing, are more briefly dealt with.

The fifth chapter, "Geologic Structure", is concerned with the structural features in the coastal plain and their relation to ground water movement. The structural features include anticlines, synclines, domes, and faults.

Chapter VI, "Description of Ground Water Basins", identifies the boundaries of the ground water basins contained within the coastal plain and takes up, basin by basin, the extent, thickness, and lithology of the aquifers and aquicludes within each. The connections between the different aquifers, the areas where recharge to the aquifers is possible from the ground surface, and the effects of structural features on the movement of ground water through the basins is also discussed.

The last chapter, "Concluding Remarks", presents a brief statement on the value of the data contained in this report, and recommendations on possible expansion of the data-collection activities.

CHAPTER II. GEOLOGIC HISTORY

The geologic history of the coastal plain of Los Angeles County is exceedingly complex. Part of the area under study, the Santa Monica Mountains, is included in the Transverse Range geomorphic province, while the rėst of the area is in the Peninsular Range province. Each of these two major geomorphic provinces has its own history of development and only large scale earth movements has affected both provinces simultaneously.

The physiography, structure, stratigraphy, and paleontology of an area must be carefully considered in any geologic history, and each subject is complex in its own way. The physiography or development of land forms and their relations to one another, are the product of periods of deformation, deposition of sediments, sea level changes, and erosional patterns. As for structure, pre-Pleistocene geologic structures are not always oriented in the same direction as structures formed since the Pleistocene began. The complex stratigraphy of the area has been further complicated by authors who have assigned different names to the same formation found in separate localities. Finally, paleontological data, in many cases essential to the proper identification of formations, are often lacking in critical areas, especially in sediments of Pleistocene age.

Succeeding sections of this chapter discuss the geologic history of the area of investigation and the broader scale regional geologic events which have played a role in that history. Some of the general features of the area of investigation and the surrounding region are shown on Plate 1, entitled "General Geology and Location of Area of Investigation". For the purposes of the discussion, four major periods are treated: pre-Miocene, Miocene-Pliocene, Pleistocene, and Recent. The geologic history as presented in this chapter is of a general nature, leaving much of the more detailed historical relationships of the various formations to be discussed in succeeding chapters. The time divisions employed in discussing geologic events is that employed in most standard geologic publications and is illustrated on Plates 3A and 3B, entitled "Areal Geology". These plates also delineate the detailed areal geology compiled from various sources for this investigation.

Pre-Miocene History

Sediments deposited during the Triassic period are found in the Santa Monica Mountains and other areas of Southern California. Rocks similar in lithology to Jurassic rocks in other parts of California have been identified in the offshore islands, on the Palos Verdes Hills, on the San Pedro shelf in San Pedro Bay, and in Orange County, suggesting relatively widespread deposition of materials in Jurassic time. These Triassic and possibly Jurassic sediments were metamorphosed as a result of rock deformation and intrusions of igneous rocks, perhaps in Jurassic time, and certainly in Cretaceous time. The early history of the region is summarized by E. S. Larsen, Jr. et al in United States Geological Survey Bulletin 1070-B, "Lead-Alpha Ages of the Mesozic Batholiths of Western North America", (1958), a portion of which is as follows:

> "In southern California, the succession of events bearing on the age of the batholith is deposition of fossiliferous Triassic rocks, folding and mild metamorphism during the Triassic, deposition of volcanic rocks and associated sediments of possible Jurassic age, folding and metamorphism of all these rocks, intrusion of the batholith, erosion to a mature surface, deposition of gravels, followed by deposition of fossiliferous Upper Cretaceous sediments (Larsen, 1948). The batholithic rocks are thus certainly younger than the Triassic rocks and older than the Upper Cretaceous sediments. On the basis of regional evidence Larsen (1948) considered them to be early Late Cretaceous."

The Southern California batholith was intruded over a period of about nine million years ranging from 105 to 114 million years ago. This batholithic intrusion emplaced the granite and granodiorite which now underlie two large areas within the coastal plain. One of these is the "high", or upthrown block, underlying the Torrance Plain and the Palos Verdes Hills, and the other is the downdropped block beneath the Downey Plain; these features are shown on Plate 2 entitled "Physiographic Features and Ground Water Basins". The position of the basement rock has been verified in some areas by deep oil wells. The boundary between these two blocks is a fault system which lies beneath the Newport-Inglewood belt of hills.

Sediments of Early Cretaceous age have not been identified within the coastal plain. Lead-alpha dating of the granitic rock underlying the coastal plain indicates that this rock was probably being emplaced at that time and therefore that period was probably one of uplift and erosion. Portions of the Downey Plain, however, are believed to be underlain by Cretaceous sediments that were laid down upon the irregular surface of the crystalline basement. In the Torrance Plain, Cretaceous sediments are missing. Upper Cretaceous continental sediments, although not identified in the deeper parts of the coastal plain within Los Angeles County, were deposited unconformably on older formations in the Santa Monica and Santa Ana Mountains. In the Santa Monica Mountains an unconformity at the top of these basal continental Upper Cretaceous rocks indicates that some tilting occurred prior to the deposition of the overlying marine Upper Cretaceous sediments.

After minor structural deformation and erosion, marine sediments of Paleocene and Eocene age were deposited where the Santa Monica Mountains and the Santa Ana Mountains are now found, and probably on the coastal plain. During these two epochs, the area west of the Newport-Inglewood uplift was probably a physiographic "high" (Corey, 1954). After another period of deformation and erosion, continental sediments of Oligocene age were deposited in some areas. These continental beds indicate that at least part of the region was above sea level in Oligocene time. Geographic distribution of the highlands and the shorelines at that time are only vaguely known.

Miocene and Pliocene History

Deposition of marine sediments resumed in early Miocene time, accompanied by intrusion and extrusion of as much as 4,000 feet of basaltic material. An orogeny or series of orogenic movements during mid-Miocene time caused differential depression of the existing early Miocene features and further encroachment of the sea. The main embayment affecting the Los Angeles area, known as the Capistrano embayment (Reed, 1943), extended in a northwesterly direction across Orange County to the vicinity of Los Angeles. The landward end of this embayment has been referred to in geological literature as the Los Angeles Basin. The embayment served as a catchment area for materials being eroded from surrounding highlands. It reached a maximum size during middle and upper Miocene time. As sediments collected in the downwarped basin, areas around the margins were uplifted, exposing more material to weathering and erosional processes. Thus the elevation of the source areas controlled the rate of deposition.

Emery (1960) states that the series of ocean basins now found off Coastal Southern California also originated in the Miocene epoch. As the Los Angeles Basin filled with sediments, the excess material overflowed into adjacent, nearshore basins. As these nearshore basins filled, the sediments spilled into basins farther from shore. This process of filling and overtopping continues within the present offshore basins.

Repeated unconformities in the sediments around the margins of the basin are primarily the result of the tectonic activity which accompanied the great downwarping of the basin and the rising of the adjacent highlands. By late Miocene or early Pliocene time the depth of the ocean embayment reached approximately 4,000 to 6,000 feet. Sediments approaching 5,000 feet in thickness were deposited during early Pliocene time. The shoreline extended to the east at least as far as Pomona and north as far as the San Gabriel Mountains. All features now on the coastal plain, including the Newport-Inglewood uplift, were probably minor subsea features, if indeed they existed at all. During late Pliocene time the downwarped Los Angeles basin became shallower and more limited in extent as it filled with another 3,500 feet of sediments. By the end of the Pliocene epoch the coastal plain had undergone repeated cycles of erosion and deposition accompanied by folding and faulting of the pre-existing sediments.

To summarize the geological events up to the end of Pliocene time: The Southern California batholith was emplaced during the Jurassic-Cretaceous epochs followed by further deposition and differential earth movements. During mid-Miocene time continued earth movement formed the embayment which contains the present coastal plain and raised the adjacent highlands. From mid-Miocene time until the end of Pliocene time the basin became shallower as it filled with sediments.

Sediments deposited during these early periods are for the most part nonwater-bearing. However, in some areas, potable water is present in the Pliocene sediments and in the older rocks.

Pleistocene History

The Pleistocene epoch is generally considered to have begun approximately 1,000,000 years ago. Major glaciation occurred at least four times during this epoch and caused fluctuations in sea level of at least 400 feet. The geologic events of Pleistocene time are illustrated on Plate 4, entitled "Generalized Pleistocene Chronology, Coastal Plain of Los Angeles County". The interpretation of events shown on Plate 4 were based on data collected during the course of this investigation, and time unit and sea level changes are modified from previous work by Hinds (1952), Fairbridge (1958), Hopkins (1959), Flint (1957), and others.

The shoreline during early Pleistocene time extended along the south side of the Santa Monica Mountains, and probably across the San Gabriel Valley, north of the area now occupied by the Elysian, Repetto, Merced and Puente Hills. These hills were offshore features in the process of emerging from the sea. From here, the sea apparently extended in a southeasterly direction along the southwestern edge of the Santa Ana Mountains.

Depth of the water in the Whittier Narrows area, according to microfossil data, exceeded 500 feet. Location of the old shoreline in the vicinity of the present Elysian, Repetto, Merced, and Puente Hills is based on marine fossils found in lower Pleistocene deposits in the vicinities of Whittier and Los Angeles Narrows. The Palos Verdes Hills were also covered by the ocean during early Pleistocene time. As time progressed, all these areas were elevated above sea level. Such larger physiographic features as the Santa Monica Mountains, San Gabriel Mountains, and the Santa Ana Mountains in Orange County probably existed at least as subsea features since early Miocene time. During Pliocene and Pleistocene time these mountains were being uplifted to their present elevations.

Uplift, accompanied by erosion, was relatively rapid in some areas but slow in others. Meanwhile the downdropped areas continued to subside and the Coastal Plain of Los Angeles County was filled with more than 1,300 feet of sediments in early Pleistocene time. These sediments constitute the San Pedro formation. The Newport-Inglewood uplift is the only geologic feature on the coastal plain which may have occasionally risen above the surrounding flat-lying areas.

A very important unconformity separates lower and upper Pleistocene sediments throughout most of the California Coast Ranges. The orogeny suggested by this unconformity has been called the "Pasadena" or "Coast Range" disturbance (Reed, 1943b, p. 118). This hiatus, as shown on Plate 4, also referred to as the mid-Pleistocene orogeny, separates sediments which are of early and late Pleistocene age. The available evidence suggests, however, that several disturbances took place during the Pleistocene epoch and that the time of the unconformity could vary from area to area as erosion took place with each new uplift.

In spite of the relatively short span of geologic time involved, the rate of deformation in the coastal plain is adequate, if assumed continuous, to have formed most of the present features since the beginning of Pleistocene time. The assumption that tectonic activity has been continuous from the Pleistocene to the present time is supported by two pieces of geologic evidence. First, upper Pleistocene marine terraces are found on the Palos Verdes and Elysian Hills and on the Santa Monica Mountains at elevations varying from 200 feet to 1,000 feet above the present sea level. Equivalent terraces elsewhere are probably buried beneath the coastal plain or have been removed by erosion. Secondly, differential tilting and deformation of Pleistocene and Recent aquifers has occurred, and changes in drainage patterns, wind gaps, and other features may have been caused in part by tilting or by uplift.

At the beginning of late Pleistocene time the Santa Monica Mountains, the Elysian Hills, Repetto Hills, Merced Hills, and the Puente Hills apparently were not as high above sea level nor as rugged as they are at the present time. They did, however, form the ocean shoreline of late Pleistocene time.

Marine fossils in upper Pleistocene sediments near the cities of Santa Monica, Beverly Hills and Los Angeles indicate that at one time the ocean extended inland across the La Brea Plain. Physiographic features similar to those of the La Brea Plain are found in the Montebello Plain. Together, they suggest that an upper Pleistocene shoreline existed near the south edge of the Repetto and Merced Hills. No certain evidence has been found that upper Pleistocene marine sediments were deposited in the vicinity of the Coyote Hills, although one late Pleistocene marine fossil locality has been reported (Hoskins, 1954). The lack of upper Pleistocene marine terraces and the continental nature of the Pleistocene deposits within the inland valleys led Eckis (Calif. D.W.R., 1934) to infer that late Pleistocene seas never extended inland beyond the present margins of the coastal plain.

Throughout late Pleistocene time sediments were being deposited primarily in the downfolded areas of the coastal plain and, probably simultaneously, were being deformed to some extent along such uplifts as the Palos Verdes Hills, Repetto Hills, Puente Hills, and possibly the Santa

Monica Mountains. These late Pleistocene sediments are named the Lakewood formation in this report. The period during which they were being deposited is illustrated on Plate 4. The Newport-Inglewood belt of hills may have existed as a line of very low hills in late Pleistocene time. These hills were undergoing continuous folding and faulting, but in general, deposition seems to have been the predominant process during this time. Outcrops clearly indicate that the basal portion of these upper Pleistocene deposits have been tilted as much as eleven degrees near areas of uplift, and have been downwarped beneath the present surface of the Downey Plain.

Although the western portion of the coastal plain was below sea level during at least part of late Pleistocene time, the nature of the upper Pleistocene deposits indicates that the shoreline apparently fluctuated and the resulting deposits are extremely complex.

World-wide changes of sea level during Pleistocene time caused the oceans to withdraw several times from the coastal plain. This was combined with intermediate periods of advance of the ocean onto the land. These recessions and advances occurred independently of the land movements. Plate 4 shows diagrammatically the possible fluctuations of sea level in Pleistocene and Recent times with suggested dates for each fluctuation. Withdrawals of the ocean caused erosion, and a rise in sea level caused deposition. That both of these conditions occurred at least once in late Pleistocene time is clearly seen in the stratigraphic sequences in the coastal plain. At least one deposit of marine sand (which now comprises the Gage aquifer) was exposed as the sea level fell, probably during the Illinoian glacial stage. A channel was eroded into these deposits by a river, or rivers, entering the coastal plain through the Los Angeles or Whittier Narrows or both. The resultant channel formed by these streams extended, not toward Dominguez Gap as does the present Los Angeles River, but westerly toward Gardena and Redondo Beach. This channel was backfilled, with coarse river gravels that form the present Gardena aquifer,as sea level rose because of the melting of the Illinoian stage glaciers.

As sea level continued to rise (probably during the beginning of the Sangamon interglacial period),portions of the Gardena aquifer inland from Lynwood were removed by wave action, and what remained was then covered by marine sands, silts, and clays. These new sand deposits cannot now be differentiated from the lower sands, and together they form the Gage aquifer.

All evidence of the stream which flowed through the Gardena and Redondo Beach areas, as well as the Gage aquifer, was eventually covered by deposition of shallow marine silts, clays and some sands. In the El Segundo Sand Hills these deposits (exposed in deep cuts in 1957 and 1958) consisted of beach sands. These beach sands extended across what is now Ballona Gap onto Ocean Park Plain where they were partly interfingered with later upper Pleistocene alluvial fans deposited by streams emanating from the Santa Monica Mountains. Erosion has subsequently removed the dunes and underlying materials from Ballona Gap. Further inland, alluvial material was being deposited concurrently by the major stream systems. Since deposition of the Gage and Gardena aquifers and the overlying fine-grained sediments, they have all been slightly folded and cut by minor faults along the Newport-Inglewood uplift.

During the last lowering of sea level, at the beginning of the Wisconsin glacial stage, it appears that the beach sands along the El Segundo-Redondo Beach area were exposed to the winds and blown inland to form the present El Segundo Sand Hills and part of the Ocean Park Plain. As sea level fell and the sea retreated, the Los Angeles and San Gabriel River systems eroded the upper Pleistocene sediments, forming Dominguez Gap. Streams draining the Santa Monica Mountains across the Sawtelle Plain and the Hollywood Piedmont Slope cut through the El Segundo Sand Hills and probably the Baldwin Hills to form Ballona Gap. At various times, the Los Angeles River and possibly the Rio Hondo-San Gabriel River system drained seaward through Ballona Gap. Since the last rise of sea level (post-Wisconsin or Recent time), the Los Angeles and San Gabriel River systems have reached the sea mainly through Dominguez and Alamitos Gaps, respectively.

Fluctuations of sea level associated with the last glacial stage have been rather complex in other portions of the world and available evidence indicates that such fluctuations were complex in this region as well. Because of these complexities it is almost impossible to tell at which period any given sand or gravel was deposited or when any given gap in the coastal plain was cut or backfilled.

Wind gaps in the Santa Monica Mountains, and the Elysian, Repetto, Merced, and Puente Hills indicate that streams other than those now existing have flowed from the San Fernando and San Gabriel Valleys across what are now the bordering highlands into the present coastal plain. Most of these streams probably were formed while the bordering highlands and mountains were being raised.

Recent History

Recent geologic time, as defined in this report, began with the melting of the last extensive world-wide glacial ice sheets. This event began about 15,000 years ago according to Shepard (1956) and Hopkins (1959), and evidently occurred rapidly, for the sea level rose at an accelerated rate. Coarse gravels were deposited or backfilled in the stream channels throughout the coastal plain. In Ballona Gap such material is found up to 60 feet below the present sea level. This stream aggradation was accompanied by wave erosion of the marine terrace deposits on exposed beaches and by marine deposition offshore. About 9,000 years ago the rate of sea level rise began to decrease and, as stream gradients decreased, finer materials were deposited in Dominguez and Ballona Gaps. Baymouth bars cut off the mouths of streams at various times, forming lagoons and playa lakes. At the present time Dominguez, Ballona, and Alamitos Gaps all contain considerable lagoonal deposits at shallow depth. The sea level was stabilized near its present level about 4,000 years ago, though a slight sea level rise occurred about 1200 A. D. which may have led to deposition of the peat now found in some areas near the coast.

Events that have occurred during the period of recorded history may help to reveal what has happened during the geologic past. Prior to 1825 and again during the flood of 1867-68, the Los Angeles River flowed westerly from the Los Angeles Narrows through Ballona Gap instead of south through Dominguez Gap. It is reasonable to assume that if rapid changes in the drainage patterns can occur in such a short time they may have occurred many times in the geologic past. The Santa Ana River is shown on older United States Geological Survey topographic maps as flowing westerly from the mouth of Santa Ana Canyon across Orange County in the direction of the present Coyote Creek drainage. The sediments which fill the basin, creating the flat, tilted plain that now exists, probably were deposited by streams migrating back and forth across the coastal plain.

Earthquakes occurring during historic times indicate that the coastal plain and surrounding highlands are still actively being folded and faulted. Deposition of active dune sands along the coast bordering

Santa Monica Bay and erosion and deposition of sediments by streams and by the ocean, is continuing where not controlled by man.

CHAPTER III. PHYSIOGRAPHY

This chapter describes the land forms or physiographic features in and surrounding the Coastal Plain of Los Angeles County. Within the area of investigation portions of two geomorphic provinces are present. The coastal plain is in the northwest corner of the Peninsular Range geomorphic province, which extends southward into San Diego County and Baja California. The Peninsular Range province consists of essentially northerly and northwesterly trending mountain ranges and associated valleys. This province is bordered on the north by the Transverse Range province, an east-west trending series of mountains which include the Santa Monica and San Gabriel Mountains. The northern portion of the coastal plain is a part of the transition area between these two major geomorphic provinces and the physiographic features reflect the complexity of the underlying structure caused by the abruptness of this transition.

The major land forms of the coastal plain consist of bordering highlands and foothills, older plains and hills, and younger alluvial plains, the rivers which drain the area, and the offshore topography. Names of land forms utilized by Poland, _et al_., (1945, 1956) are used herein except where additional features have been named, and their locations are shown on Plate 2.

Bordering Highlands and Foothills

Highland areas adjacent to the coastal plain include the Santa Monica Mountains, the Palos Verdes Hills, and the Puente Hills. All of these features are geologically young in origin, moderate to bold in relief, and generally mature in form.

The highest elevations on these highlands within the area of investigation are: Santa Monica Mountains, 2,126 feet; Puente Hills, 1,387 feet; and the Palos Verdes Hills, 1,480 feet. The highland areas are more or less gullied and incised by streams, though extensive relatively smooth surfaces remain which have not been entirely removed. These smooth surfaces and their associated subdued hills and valleys are possibly remnants of an old erosion surface (Eldridge and Arnold, 1907), which has been deformed, uplifted, and removed in most areas by more recent erosion.

Thirteen wave-cut terraces on the Palos Verdes Hills, extending up to 1,300 feet above sea level, have been identified by Woodring, et al., (1946). Similar wave-cut terraces have been described in the Santa Monica Mountains and offshore islands (i.e., San Miguel, Santa Rosa, and Santa Cruz Islands) to the northwest and west of this area, but within the coastal plain only the equivalent of the lower terraces have been identified. As mentioned in the chapter on geologic history, these terraces indicate continued uplift of the highland areas in late Pleistocene time.

The highland areas generally consist of relatively impermeable rocks which yield little water to wells. Minor springs and seeps add to direct runoff from precipitation and are probably a negligible source of supply to adjacent water-bearing areas. Springs and seeps contribute to slope stability problems in certain areas.

The foothills are the Elysian, Repetto, and Merced Hills. These hills are mostly underlain by Tertiary rocks and may have been one continuous surface at some time in the past (Poland, et al., 1956). These features, like the highlands, are geologically young. The Elysian and Repetto Hills are now separated by the Los Angeles Narrows, and the Repetto and Merced

Hills are separated by an abandoned stream channel along Potrero Grande Drive. Whittier Narrows separates the Merced Hills from the Puente Hills.

Maximum elevations in the foothills are: Elysian Hills, 757 feet; Repetto Hills, 735 feet; and the Merced Hills, 550 feet. These features have moderate relief and have been considerably eroded. Probable wind gaps are present in the Elysian Hills along Los Feliz and Silverlake Boulevards. Wind gaps are also present in the Repetto Hills north of Boyle Heights, east of City Terrace, and along Eastern Avenue, Monterey Pass Road, Atlantic Boulevard and Potrero Grande Drive.

The Tertiary sediments in these foothills are essentially nonwater-bearing. Water-bearing materials are present only in small thin patches and supply little water to wells.

Older Plains and Hills

Many physiographic features in the coastal plain are characteristically covered with a reddish, or brown, deeply weathered soil formed prior to Recent time. In some areas this soil and the surface which it forms may be in its original position, but in many areas both it and the underlying sediments have been warped, folded, faulted and at least partially eroded away. In other areas this deeply weathered soil has been downwarped and covered with younger alluvial material.

Land forms characterized by the red weathered soil include older dissected alluvial aprons, the Coyote Hills, older marine plains, the El Segundo Sand Hills, and the Newport-Inglewood belt of hills. Most of these land forms were formed at essentially the same time and have been deformed and eroded to about the same degree. The Coyote Hills, near the eastern boundary of the county, and the Baldwin and Signal Hills, which are part of the Newport-Inglewood belt of hills, have been uplifted and eroded to a greater degree than most of the other features included in this group. Available evidence suggests, however, that a deeply weathered soil was formed on these features before the latest erosional cycle began.

Older Dissected Alluvial Aprons

The older dissected alluvial aprons are located adjacent to the highlands and foothills previously described. In this category are the Santa Monica Plain, La Brea Plain, Montebello Plain, and the Santa Fe Springs Plain. Their locations are shown on Plate 2. Soils of deeply weathered, reddish material, 3 to 20 feet thick, have developed on the surface of these alluvial aprons. Within this soil profile, rock fragments, cobbles and boulders are commonly deeply weathered and soft. These soil features are easily recognized in most of the areas where they have been preserved from erosion. The older dissected alluvial aprons are generally underlain by water-bearing sediments of considerable thickness. Some parts of these areas are susceptible to recharge, and changes in ground water storage could occur in some underlying aquifers.

Santa Monica Plain. The Santa Monica Plain lies along the south flank of the Santa Monica Mountains and extends from the ocean inland to the Newport-Inglewood belt of hills. The plain has been dissected by streams draining the Santa Monica Mountains. Streams draining Sepulveda, Dry, Stone, and Brown Canyons have eroded and back-filled an area near Sawtelle, leaving a surface which slopes to the southeast and lies at a lower elevation than the Santa Monica Plain. This area, referred to as the Sawtelle Plain in this report, is discussed under a subsequent subheading - Alluvial Aprons. The Santa Monica Plain was originally deposited, however, in the form of several large alluvial fans which overlapped onto the Ocean Park Plain and Beverly Hills. Remnants of the surface of these fans are found 175 feet to about 500 feet above sea level. Gradients from apexes to the lower end of the surfaces average about 150 feet per mile.

La Brea Plain. The La Brea Plain is located east of the Newport-Inglewood belt of hills and west of the Elysian Hills. A surface was originally cut by the sea during Pleistocene time on lower Pleistocene and older formations. On this eroded surface 90 to 200 feet of alluvial sediments have been deposited, the top of which now forms the La Brea Plain.

The La Brea Plain has apparently been warped into an east-west anticlinal structure extending westerly from the Elysian Hills. Because of this warping and partial uplifting, the plain is being dissected and removed by erosion. A younger series of alluvial fans forming the Hollywood piedmont slope have buried the La Brea Plain from the north. Poland, et al., (1956) described the La Brea Plain and the Santa Monica Plain as being of similar origin, and additional exposures and close study of the land forms indicate that both of these forms are related in age to the Ocean Park Plain and the Torrance Plain.

Montebello Plain. The Montebello Plain extends south of the Repetto and Merced Hills between the Los Angeles River and the Rio Hondo and has been folded by an east-west anticlinal flexure extending westerly from the Montebello oil field. South of this anticlinal area, the Montebello

Plain dips very gradually toward the Downey Plain and continues beneath a portion of it. In the area which has been affected or folded by the extension of the Montebello anticline, the Montebello Plain has been dissected by small streams draining southward from the Repetto Hills, forming deep gullies crossing the axis of the fold. Along the north side of the Montebello Plain near Boyle Heights, the physiographic relationships suggest that a marine-cut terrace was formed prior to deposition of the alluvial materials that now form the present surface of the Montebello Plain in that area. However, fossil evidence supporting this theory is absent.

Santa Fe Springs Plain. The Santa Fe Springs Plain is located south of Whittier and east of the San Gabriel River, in the area of the City of Santa Fe Springs, and is apparently a continuation of the Coyote Hills uplift to the southeast. The Santa Fe Springs Plain is only a low, slightly rolling topographic feature unlike the somewhat rugged Coyote Hills to the southeast. The Santa Fe Springs Plain has probably been warped by the Santa Fe Springs-Coyote Hills anticlinal system and dips gently both to the northeast toward Whittier and to the southeast toward the Downey Plain. The difference in elevation ranges from 100 to 175 feet above sea level.

Coyote Hills

The Coyote Hills, a youthful anticlinal feature, are most developed in Orange County. The feature continues northwesterly into Los Angeles County where it becomes a low hill dissected by streams and grades gradually into the Santa Fe Springs Plain.

Maximum elevation in the Coyote Hills is 600 feet above sea level and occurs in Orange County. The hills that lie to the west of La Habra Road and in the area of investigation have elevations of approximately 25 feet to 325 feet above sea level. The north slope is steeper than the south, which grades gradually into the Downey Plain.

Older Marine Plains

The Older marine plains include the Torrance, Long Beach, and Ocean Park Plains, all of which have similar histories and are closely related to the Newport-Inglewood belt of hills. All of these plains are underlain by water-bearing sediments.

During upper Pleistocene time, it is probable that the Ocean Park Plain continued undisturbed southward and was united with the El Segundo Sand Hills and Torrance Plain. The Torrance and Long Beach Plains, originally one, have been separated by downcutting of the Los Angeles-Rio Hondo-San Gabriel River systems. Landing Hill, part of the Newport-Inglewood belt of hills, and Long Beach Plain have been separated because of erosion by Coyote Creek and possibly the Rio Hondo and San Gabriel River.

Much attention has been given to the fact that marine fossils are commonly found from 10 to 30 feet below the surface of the Long Beach, Torrance, and Ocean Park Plains. Fresh water fossils have also been observed in shallow deposits in the Torrance Plain near Dominguez Creek. Many remains of extinct land mammals have been found in this same thickness of sediments in the Long Beach and Torrance Plains. These fossils suggest that there were periods of complete or nearly complete emergence of the land between periods of subsidence so that both land and sea animals could have access to the area.

Ocean Park Plain extends inland from the Pacific Ocean approximately three miles bordering on the north of Ballona Gap. Elevation on the plain ranges from sea level to 200 feet above sea level. Poland, _et al_., (1956) lists three physiographic areas within the plain: a bench on the eastern portion, a central unit with an undulating surface, and a ridge-and-trench area on the western portion. His ridge-and-trench area is equivalent to the El Segundo Sand Hills to the south. The Ocean Park Plain is slightly dissected by local streams.

The Torrance Plain parallels the Newport-Inglewood belt of hills from Ballona Gap southwest to Dominguez Gap. It is a broad featureless area only slightly dissected by local streams north of Centinela Creek and cut in the south by Dominguez Creek. The plain is immediately underlain by fine-grained materials of marine and nonmarine origin, and in small low lying areas the fine-grained materials are overlain by Recent alluvium.

The Long Beach Plain is located on the southwest side of the Newport-Inglewood belt of hills between Dominguez and Alamitos Gaps. This plain is underlain by the same kind of sediments as the Torrance Plain; however, no aquifers have been delineated in this area.

El Segundo Sand Hills

The El Segundo Sand Hills extend from Ballona Gap south to Torrance and the Palos Verdes Hills, and approximately three to four miles inland from the ocean. Remnants of similar hills are found on the western edge of Ocean Park Plain. The sand hills consist of a narrow strip of active or recent dunes along the coast and older stabilized sand dunes inland. The active dunes are up to one-half mile wide, with a maximum elevation of 185 feet above sea level. These active dunes have undergone at least two stages of development, as shown by excavations for the Scattergood Steam Plant of the Los Angeles Department of Water and Power near El Segundo. A earlier phase of the recent unweathered sand dunes had a surface which was inhabited by man and subsequently covered with over 30 feet of sand to form the present dunes.

The active dunes are underlain by older sand dunes of probable late Pleistocene age. In several areas of the El Segundo Sand Hills, fossils and sedimentary features in excavations indicate that these older sand dunes were originally beach deposits which have been altered in form by wind action and deeply weathered. These beach deposits resemble in many respects the marine and underlying portions of the Torrance and Long Beach Plains and are probably contemporaneous with them. The form of the older beach sands was modified by the wind so that the surface now has closed depressions. The closed depressions have been formed by a combination action of removing and piling up of sand. One to three miles inland, the older sand dunes overlie silts and clays which apparently were deposited on the landward side of the beach sands and which now form a portion of the Torrance Plain. Weathering and associated stabilizing processes have removed all but the gross features of dune topography in the older sand dune area. Thin remnants of similar dune sands have been observed in excavations for the Harbor Freeway on the Rosecrans Hills.

Newport-Inglewood Belt of Hills

The area of deformation that extends from the foot of the Santa Monica Mountains near Beverly Hills southeasterly as far as Newport Beach in Orange County is named the Newport-Inglewood belt of hills and plains. As originally defined by Poland, *et al.*, (1956), this belt of hills and plains included the Torrance and Ocean Park Plains; however, in this report the term Newport-Inglewood belt of hills is used to delineate the area of deformation exclusive of the Torrance and Ocean Park Plains which have been described separately. The area of deformation varies in width from one to four miles and is underlain by a series of folds and faults which have given rise to most of the surface hills, plains, and mesas. For this reason, in discussions of structural geology this belt of hills is referred to as the Newport-Inglewood uplift. Poland's findings indicate that the many features of the Newport-Inglewood belt of hills and plains are of the same age as the Torrance and Ocean Park Plains. Observations during this investigation support this conclusion.

In the Newport-Inglewood belt of hills, the surface is frequently underlain by a highly weathered reddish colored soil which is itself underlain by sand and silt containing marine fossils. This sand and silt was deposited in a shallow sea or lagoonal environment. The original surface, after withdrawal of the sea, extended into Ocean Park Plain, Beverly Hills, and possibly the La Brea Plain. The marine-formed surface may have extended to the Montebello Plain, although fossil evidence has not been found to substantiate this theory. In general, the upper Pleistocene sediments have been strongly deformed in some areas along the uplift and completely removed by erosion in others.

The following paragraphs briefly describe the various features that comprise the Newport-Inglewood belt of hills, all of which are underlain by water-bearing sediments.

The Beverly Hills are the most northerly feature of the Newport-Inglewood belt of hills which have easily identifiable topographic characteristics. They range in elevation from 75 feet to 300 feet above sea level.

The area displays a rolling topography, as a result of warping and of erosion by local streams. The marine upper Pleistocene deposits capping Beverly Hills were probably continuous with the Ocean Park and Torrance Plains and with remnants of similar sediments which now cap Baldwin Hills. The Beverly Hills apparently have been warped and faulted. In a small area near Cheviot Hills, which is a portion of Beverly Hills, lower Pleistocene marine sediments are exposed (Rodda, 1957); elsewhere they are overlain by marine upper Pleistocene deposits.

The Baldwin Hills, south of Ballona Gap, are a prominent feature extending some 513 feet above sea level and more than 400 feet above the central lowlands to the east and northeast. Sediments of the Baldwin Hills have been considerably warped and faulted. The north flank of the Baldwin Hills has been deeply incised by erosion, whereas the south flank slopes gently to the Torrance Plain and Rosecrans Hills.

The Rosecrans Hills, beginning near Inglewood and extending southward to Dominguez Hill, comprise a low swell about three miles wide with its crest ranging from 100 to 240 feet above sea level. The surface of the Rosecrans Hills is underlain by upper Pleistocene sediments which dip southwesterly toward and merge with the Torrance Plain and northeasterly toward and probably beneath the Downey Plain.

Dominguez Hill, an anticlinal dome with a northwest-southeast trending axis, is located just northwest of Dominguez Gap. On the west and north, Dominguez Hill grades into the Torrance Plain and the Rosecrans Hills. Elevations range from 20 feet to 195 feet above sea level. Little erosion has occurred on the hill to modify the surface topography, with the exception of the east flank where a local stream has cut a deep gully, and on the southeast where the Los Angeles River has eroded into the hill.

Signal Hill, Bixby Ranch Hill and Bouton Plain were grouped by Poland, _et al_., (1956) as the Signal Hill uplift, but are considered to be separate though related features in this report. Signal Hill, southeast of Dominguez Gap, rises to an elevation of about 365 feet above sea level. Its southwesterly side is approximately bounded by a fault scarp. The north side of Signal Hill slopes gradually down to the Bouton Plain, which in turn slopes northerly toward the Downey Plain. On Signal Hill the upper Pleistocene sediments have been folded and eroded to such a degree that they have been removed, exposing the lower Pleistocene sediments in small areas. Southeast of Signal Hill is Bixby Ranch Hill, which is located to the northwest of Alamitos Gap. The south and north sides of Bixby Ranch Hill are apparently closely related to fault scarps.

Landing Hill, although just across Alamitos Gap in Orange County, is another feature of the Newport-Inglewood belt of hills. The surface slopes to the northeast beneath the Downey Plain and is capped with the same type of sediments as those on Signal Hill and the remainder of the Newport-Inglewood belt of hills.

Younger Alluvial Plains

Younger alluvial plains include those areas where alluvium has been deposited in Recent time. The alluvial material has buried parts of the older weathered surface. The younger alluvial plains have been grouped into alluvial aprons and the Downey Plain. All of these areas are underlain by water-bearing material.

Alluvial Aprons

The younger alluvial aprons consist essentially of coalescing alluvial fans or alluvial piedmont slopes which have overlapped in Recent time some of the older Pleistocene plains previously mentioned. These younger alluvial aprons include the Sawtelle Plain, Hollywood piedmont slope and the La Habra piedmont slope.

The Sawtelle Plain is essentially a thin sheet of alluvium deposited on an eroded surface in the area surrounded by the Santa Monica and Ocean Park Plains and Beverly Hills. Alluvium in the Sawtelle Plain appears to be relatively thin, possibly no more than 30 or 40 feet deep. The surface slope averages between 60 and 80 feet per mile.

The Hollywood piedmont slope lies south of the Santa Monica Mountains, north of the La Brea Plain, and east of the Newport-Inglewood belt of hills. This area consists of several small alluvial fans deposited by streams draining from the Santa Monica Mountains. These fans form a relatively flat surface, with minor undulations, that slopes to the south and southwest with a gradient of about 90 feet per mile. The small coalescing fans are approximately 100 feet thick near the base of the Santa Monica Mountains, but to the south near Beverly Hills, excavations indicate that they decrease to a thickness of 10 to 30 feet. The Hollywood piedmont slope has been deposited partly on the La Brea Plain, Beverly Hills, and the Elysian Hills. Along the north side of Ballona Gap, sediments from the Hollywood piedmont slope and from Sawtelle Plain have been deposited as small alluvial fans. These small fans are moderately thick and have overlapped and become interbedded with sediments of Recent age deposited by the Los Angeles River which, as late as 1868, flowed through Ballona Gap into the ocean near Venice.

The La Habra piedmont slope extends southeasterly along the southwest foot of the Puente Hills from Whittier Narrows into Orange County.

This area consists of several small alluvial fans deposited by streams draining the Puente Hills. These fans coalesce forming an undulating surface that slopes to the south and southwest with a gradient of about 170 feet per mile. This area has been more extensively dissected than has the Hollywood piedmont slope. As a result of this dissection, the topographic expression of the La Habra piedmont slope is quite complex. Some of the exposed features are probably of the same age as the Santa Fe Springs Plain and the Montebello Plain, that is, of upper Pleistocene age. Many younger fans of shallow depth cover portions of the area.

Downey Plain and Related Features

The Downey Plain, the largest area of Recent alluvial deposition, is located south and southeast of the La Brea, Montebello, and Santa Fe Springs Plains, and of the Coyote Hills, and northeast of the Newport-Inglewood belt of hills (Poland, et al., 1956). It extends from Ballona Gap across the central lowland of the Coastal Plain of Los Angeles County into the Coastal Plain of Orange County nearly to Santa Ana. The Downey Plain ranges in elevation from 275 feet in the Los Angeles Narrows and 200 feet in the Whittier Narrows to sea level at the ocean near Dominguez Gap. The slope of the Downey Plain varies from 7 to 23 feet per mile, but is generally less than 18 feet per mile. It is essentially a depositional feature, although minor erosion has occurred. Alluvial fans formed by the Los Angeles and Rio Hondo-San Gabriel River systems have coalesced to form a very gentle plain. During past flood times these large rivers have swung over most of the area depositing their debris. Near the ocean some of the stream deposited sediments are interbedded with marine and tidal sands, gravels, and clays.

Ballona Gap, located between the Baldwin Hills and Beverly Hills and extending to the ocean, was initially formed by headward erosion from the ocean, capturing drainage from the Sawtelle Plain and the Hollywood piedmont slope. Although the Los Angeles River has flowed through the Gap, available evidence indicates that it has caused less erosion than the smaller streams.

Dominguez Gap includes the lower portion of the Los Angeles River area between Dominguez and Signal Hills. It is about two miles wide and slopes toward the ocean at a gradient of about four feet per mile.

Alamitos Gap, separating Long Beach Plain and Bixby Ranch Hill from Landing Hill, has been eroded by Coyote Creek and presumably other streams. The surface slopes oceanward at the same gradient as Dominguez Gap.

The Los Angeles Narrows, located between the Elysian and Repetto Hills, is an erosional feature cut through a relatively weak portion of the Santa Monica Mountains by the Los Angeles River. Terraces and complex subsurface alluvial deposits indicate that erosion and deposition has been complex in the Narrows.

The Whittier Narrows separates the Merced and Puente Hills and forms the avenue through which drainage from the San Gabriel Valley and surrounding highlands passes to the coastal plain. The two major streams passing through Whittier Narrows are the Rio Hondo and the San Gabriel River. The width of the Whittier Narrows varies from 1.6 miles to 2 miles. Although generally flat with steep sides, the surface configuration of the Narrows is further complicated by terraces, alluvial fans from local small canyons, and abandoned stream courses and meanders. This physiographic feature appears to have been formed in late Pleistocene time, although Slosson (1958) suggests that the area was a submarine canyon in lower Pliocene time.

Drainage Systems

The Coastal Plain of Los Angeles County is drained primarily by the Los Angeles and Rio Hondo-San Gabriel River systems. Within historical times the Los Angeles River has flowed through Ballona Gap, and the Santa Ana River in Orange County has drained through Alamitos Gap. It is probable that all three river systems crossing the coastal plains of both counties have entered the ocean at various locations from Dominguez Gap on the north to Santa Ana Gap near Huntington Beach on the south.

Minor stream systems include Dominguez Creek on the Torrance Plain which drains to the ocean and Comptom Creek on the Downy Plain that enters the Los Angeles River northeast of Dominguez Hills. Coyote Creek, flowing through the Coyote Hills, now occupies a wide valley much larger than ncessary for its present flow. Physiographic evidence in the area north of Coyote Hills indicates that Brea Creek flowed down the present Coyote Creek channel in late geologic time, but has been diverted to its present channel southeast of Coyote Hills leaving the old channel to drain only its present small watershed.

Physiographic evidence is abundant that other streams have drained the San Gabriel Valley across the Repetto Hills to the coastal plain, and their courses have since been abandoned, forming wind gaps. What are probably wind gaps are also found in the Santa Monica Mountains; they may represent relatively old stream courses which drained the San Fernando Valley at the beginning of late Pleistocene time.

Offshore Physiography

Physiography of the offshore area of Southern California is well described by Emery (1954), Shepard (1948), Terry, et al., (1956), Stevenson, et al., (1958), and Gorsline and Emery (1959). This large offshore area is described briefly in this report because of the close stratigraphic and physiographic relationship it has with the onshore area covered by this investigation. The offshore features are shown on Plate 2.

The first submarine physiographic province encountered is the continental shelf. The western boundary of the continental shelf, roughly delineated by the 50 fathom contour (300 feet), parallels the coastline at distances from shore varying from a few hundred feet to 8 or 10 miles. The continental shelf slopes seaward at a gradient of about 25 feet per mile in Santa Monica and San Pedro Bays. The shelf is generally smooth, though such minor irregularities as longshore troughs, mounds, bars, and depressions occur in water less than 20 feet deep where they are constantly changing position. Such features are known as micro-relief. Along the break in slope at the outer margins of the continental shelf are terraces, steps, and notches. Submarine canyons interrupt the shelf and may represent lines of weakness or remnants of pre-existing drainage channels. A zone of bedrock mounds, more than 2,000 feet in diameter, many of which are connected by steep-sided ridges, occur approximately five to six miles offshore in Santa Monica Bay on the continental shelf.

The second major offshore physiographic province is the basin slope. This slope extends from one to ten miles seaward from the rim of the continental shelf at about 300 feet to 2400 feet below sea level with an average 450 feet per mile gradient except where it steepens near submarine canyons.

Beyond the basin slope for a distance of approximately 140 miles seaward lies a broad area of fault block structures, referred to by Shepard (1948) as the continental borderland. The downfaulted blocks are mostly closed basins separated by sills or upfaulted submarine ridges which rise about 2,000 feet above the floor of the basins. Included in the uplifted blocks are San Clemente, Santa Catalina, San Nicholas, San Miguel, Santa Rosa, and Santa Cruz Islands. Emery (1954) explains that this series of uplifted and downdropped structures may be due to faulting and/or folding.

The fourth of this series of physiographic provinces, the continental slope, begins at the edge of the continental borderland and plunges steeply to abyssal ocean depths of 12,000 feet or more.

Three subprovinces of the continental shelf named by Terry, et al.,(1956) are the Santa Monica Shelf (Point Dume to Palos Verdes Point), the Palos Verdes Shelf (Palos Verdes Point to Point Fermin), and the San Pedro Shelf (Point Fermin to Corona Del Mar) are shown on Plate 2. The Santa Monica and San Pedro Shelves are significant in respect to the occurrence and movement of ground water.

The Santa Monica Shelf extends seaward about eight miles and is subdivided into three segments by two submarine canyons that cut transversely across it offshore from Santa Mónica and Redondo Beaches.

The Palos Verdes Shelf is narrow and extends seaward about one mile from the coast of the Palos Verdes Hills. Because of the lack of water-bearing sediments in the southwestern Palos Verdes Hills and in the offshore area, the Palos Verdes Shelf is not significant for this study.

Located southeasterly from the Palos Verdes Hills is the San Pedro Shelf. This shelf extends seaward 2 miles from Point Fermin and achieves a maximum extension of 12 miles at its central projection, before it diminishes again to 2 miles off Corona Del Mar. Moore (1951) gives an account of the physiography, structure, and sediments in this area; the formations were also described by Stevenson, Uchupi, and Gorsline (1958). This flat, featureless plain slopes southward and southeastward toward the basin slope, which has here been named the San Pedro Escarpment by Shepard and Emery (1941). Erosion followed by deposition of Recent sediments has reduced both positive and negative topographic features, obliterating the ancient stream channels of the Los Angeles and San Gabriel Rivers that once crossed it.

The Santa Monica and Redondo Submarine Canyons occur along the basin slope extending westward off the Santa Monica Shelf. The Santa Monica Canyon begins about four miles offshore at a depth of 180 feet and assumes a curved and sinuous course into the Santa Monica Submarine Basin, the nearest closed basin of the continental borderland. The canyon is relatively smooth with only small tributaries entering from the south wall. The Redondo Canyon begins a few hundred feet offshore from the City of Redondo Beach, follows a straight course across the Santa Monica Shelf, and empties into the Santa Monica Submarine Basin. A steep gradient of about 400 feet per mile at the canyon head gradually decreases to about 130 feet per mile at its fan-like terminal approximately 2,200 feet below sea level. Tributaries along the north side contribute to the variable topography of the canyon walls. Slumping occurs within the canyons and along the basin slope and carries recently deposited sediments to greater depths offshore.

Subsurface evidence provides at least a partial history of the development of the Redondo Canyon. During a part of late Pleistocene time when the sea level was much lower, drainage from the San Gabriel River, and possibly the Los Angeles River, flowed across what is now the Downey Plain, Rosecrans Hills, Torrance Plain and El Segundo Sand Hills to the present head of Redondo Canyon and continued oceanward to the rim of the continental shelf. Downcutting probably occurred rapidly along the basin slope and further entrenched the stream channel landward. A rapid rise in sea level has since caused the backfilling of coarse debris in this entrenched channel.

The San Pedro Sea Valley, an east-west trending submarine canyon, begins on the San Pedro Shelf south of Point Fermin. A branch or tributary leads off from the northern side of the main valley and trends northeasterly toward the mouth of the San Gabriel River. Both the main valley and its tributary lose their identity above a depth of about 150 feet. At the eastern extremity of the San Pedro Shelf, about 10 miles south of Sunset Beach, two smaller valleys trend in a southerly direction from a depth of 150 feet. This valley system has been named the San Gabriel Canyon by Emery (1960).

CHAPTER IV STRATIGRAPHY

This chapter describes the stratigraphy, or the physical characteristics of the natural groupings of the rocks and sediments, in the Coastal Plain of Los Angeles County, including the age of rocks and sediments, their order in relationship to each other, and their position in the area. In order to simplify the discussion of stratigraphy, the rocks and sediments in the coastal plain are divided into water-bearing deposits and nonwater-bearing rocks.

The water-bearing deposits include the unconsolidated and semi-consolidated marine and nonmarine alluvial sediments of Recent, Pleistocene, and Pliocene age which form ground water basins. These materials absorb, transmit, and yield water readily to wells. Sizes of individual particles may grade from coarse gravel and boulders to clay. Coarse sands and gravels form the conduits for transmission of ground water and are called aquifers, while the finer sands, silts and clays, which also transmit ground water, but very slowly, are known as aquicludes.

The types of materials encountered by surface and subsurface geologic exploration and water well drilling, as reported by various individuals and agencies, are summarized on Table 1, which is bound at the end in this report. Based upon this information, the areal extent, thickness, and depths of the various aquifers and aquicludes underlying the coastal plain were estimated. The aquifers were named and their stratigraphic positions are illustrated schematically on Plate 5, entitled "Generalized Stratigraphic Column, Coastal Plain of Los Angeles County". Since the aquicludes which separate aquifers are generally of secondary interest, and because of additional complications of nomenclature, only the surface aquiclude is named. An attempt has been made to bring together and clarify the nomenclature used by many individuals and agencies. Therefore Plate 5 also relates the nomenclature system utilized in this report with that employed by others in the past.

The term "nonwater-bearing rocks" used in this report should not be construed to mean rocks which contain no water, but rather materials from which wells produce relatively limited quantities of water. Nonwater-bearing rocks are the parent rocks from which alluvium is derived. These rocks flank, underlie, and sometimes form the limits of the ground water basins and provide watersheds for runoff or drainage to valley-fill areas. Nonwater-bearing rocks include granitic, metamorphic, volcanic, and consolidated sedimentary types. Locally, the sedimentary rocks may yield a small amount of brackish, saline, or other poor quality waters. Water which drains from these rocks may also affect the quality of water in the sediments of valley-fill areas. Even within the crystalline basement rocks, some extractable water is contained within the joints, fractures, and solution cavities. In the highland areas, wells in volcanic flows and breccias yield limited quantities of water. The yield of wells in the volcanics, however, is usually restricted either because there is a lack of connected interstices or because they are so situated topographically or structurally that cementation, folding and faulting interferes with the vertical and lateral flow of ground water.

The following sections describe the water-bearing deposits and nonwater-bearing rocks in detail beginning with the geologically most recent, and working backward in time to the oldest strata. The surface outcroppings of the various formations are delineated on Plate 3. The conclusions of this study relating to the depth and thickness of the various aquifers and aquicludes in the coastal plain are illustrated by a series of idealized geologic sections cutting the area in east-west and north-south directions. These sections are shown on Plates 6A through 6G, entitled "Idealized Geologic Sections"; and the geographic locations of the sections are indicated on Plate 3, together with the locations of wells and test holes from which the geologic sections were derived. In addition to the wells and test holes shown on these plates, there were two to three times as many wells and test holes that were studied. These data were used to assist in delineating the boundaries of the aquifers and aquicludes.

In constructing the geologic sections, it was much easier to correlate aquifers from well log to well log in the marine sediments found southwest of the Newport-Inglewood uplift than it was in the area to the northeast. Consequently, the correlations in the continental sediments, especially those adjacent to the high lands are more definitive than are those in the marine sediments closer to the ocean. Also, the geologic sections in the West Coast Basin (this basin is described in Chapter 6) were mainly based on data taken from the Report of Referee (Calif. D.W.R. 1952a), modified slightly by unpublished data obtained from the Los Angeles County Flood Control District.

Subsurface structure and positions of aquifers in the area downstream from Whittier Narrows are illustrated by a series of cut-away diagrams shown on Plate 7, entitled "Cut-Away Diagrams of Aquifers in Vicinity of Whittier Narrows". These diagrams are of assistance in following the discussion of stratigraphic relationships but are discussed in detail in Chapter V. Detailed discussions of structural features referred to in the following sections are also contained in Chapter V.

Quaternary System

Sediments of Quaternary and late Pliocene age comprise the water-bearing formations in the coastal plain. The Quaternary deposits are divided into the Recent and Pleistocene series.

Alluvial materials and rocks of Recent and Pleistocene age usually are unconsolidated and have suffered deformation to a lesser degree than the older underlying rocks. These younger alluvial materials are generally more heterogeneous than the older sediments although this may be more apparent than real, since more detailed information is usually available for younger sediments than for those older in age. In the detailed studies of oil fields, by contrast, the heterogeneity of older sediments is apparent.

Ground water extracted from wells is obtained primarily from aquifers of Recent and Pleistocene age, with the exception of a few wells in the Lakewood and North Long Beach areas which are perforated in sediments of late Pliocene age.

Deposition of Quaternary sediments has been controlled by tectonic activity, geomorphic processes, changes in climate, and world-wide changes in sea level, as previously discussed. The physical characteristics of those water-bearing series that favor high production of ground water are: their unconsolidated and permeable nature, their relatively undeformed state, their low topographic position, which permits infiltration of drainage from higher surrounding areas, their freedom from obstructions to flow in most areas, the ease with which their materials may be dewatered, or drained, and the ease with which in certain areas they may be naturally or artificially recharged.

Recent Series

Reade (1872) first defined the Recent epoch as that time which has elapsed since the beginning of the last major rise in sea level, and this definition has been adopted for use in this report. An approximate age of 15,000 years has been assigned to the Recent epoch by Shepard (1956) and Hopkins (1959).

Recent materials were laid down upon the erosional surface that existed toward the end of the last glacial stage. In most of the Coastal Plain of Los Angeles County these sediments are stream deposits but near the ocean they include tidal, marine, and wind-deposited materials.

Recent deposits are recognizable by:their generally coarse, unconsolidated or uncemented nature (however, on Recent flood plains, alluvial fans, and certain marine deposits, fine-grained silts and clays are common), their unconformable relationship with the underlying late Pleistocene and older deposits, their relationship to the present drainage system including numerous gaps along the coast and other physiographic features, and the youthful or poorly developed soil normally found on the surface. Little deformation of the Recent sediments has occurred except where they cross tectonically active areas, as in Dominguez and Ballona Gaps. Two major members of the Recent series are shown in the areal geology presented on Plate 3 namely, alluvium, represented by the symbol Qal and active dune sand represented by Qsr.

Alluvium. Recent Alluvium is primarily stream deposited gravel, sand, silt and clay with some interbedded littoral and estuary or bay deposits near the ocean. Geologic members found within the alluvial deposits include the Semiperched aquifer, Bellflower aquiclude, Gaspur aquifer, and

Ballona aquifer. Portions of the Semiperched aquifer and Bellflower aquiclude are of late Pleistocene age, placing them in the Lakewood formation. They are described here, however, together with the deposits of Recent age.

Semiperched Aquifer. Coarse sands and gravels, called the Semiperched aquifer, are found on or near the surface of much of the Coastal Plain of Los Angeles County. These materials vary in thickness from 0 to 60 feet and may contain significant amounts of unconfined water where they are more than 20 feet thick. The most important areas where this aquifer appears are in the Los Angeles and Montebello Forebay Areas, and irregular patches occur throughout the rest of the coastal plain.

Where the underlying aquifers are confined, the Semiperched aquifer is generally separated from them by silts and clays or other material of relatively low permeability, called the Bellflower aquiclude. These materials inhibit the free percolation of water from the Semiperched aquifer to the underlying aquifers.

Permeable sediments of both Recent and late Pleistocene age are included within the Semiperched aquifer. Most of the sediments are probably remnants of abandoned stream channels, although marine deposits previously known as the Palos Verdes Sand are a part of the aquifer underlying portions of the Torrance Plain.

Little beneficial use is made of water in the Semiperched aquifer since wells perforated in it yield very small quantities of water. Furthermore, the poor quality of the water in some areas makes it undesirable for widespread use.

Bellflower Aquiclude. Lying directly beneath the Semiperched aquifer are sediments of lesser permeability which restrict vertical movement of ground water. These relatively impermeable materials, referred to in numerous reports in generalized terms, have been designated the Bellflower aquiclude. Physical features and dimensions of this aquiclude are delineated on Plate 8, entitled "Lines of Equal Elevation on the Base of the Bellflower Aquiclude", and on Plate 9, entitled "Lines of Equal Thickness of the Bellflower Aquiclude". The Bellflower aquiclude comprises all of the fine grained sediments that extend from the ground surface, or from the base of the Semiperched aquifer, down to the first aquifer below. Other names that have been used to refer to these materials are: "Upper Division of the Alluvial Deposits of Recent Age" (Poland, et al 1956); "Upper Fine Grained Phase" in California D.W.R. 1952b; and "clay cap" in California D.W.R., 1952c, 1957a, and 1958b. The flood plain deposits referred to by Poland, (1959b) which are found in many portions of the Downey Plain may be equivalent, at least in part, to the Bellflower aquiclude as here defined. Although other reports refer to these sediments as Recent in geologic age, the Bellflower aquiclude, as defined in this report, is composed of both Recent sediments in some areas, and late Pleistocene deposits in others.

The Bellflower aquiclude extends throughout most of the Coastal Plain of Los Angeles County, except for the Los Angeles and Montebello Forebay Areas. According to drillers logs and from visual observation of exposed formations in excavations, this aquiclude is a heterogeneous mixture of fine grained continental, marine, and wind-blown sediments. In about a third of the coastal plain, the aquiclude consists only of clays and silty clays, but extensive lenses and pockets of sandy or gravelly clays occur in the remainder of the area, as shown on Plate 9. These predominantly sandy and gravelly clays may permit waters to percolate slowly to the underlying aquifer or aquifers, or ground water in these latter areas may move upward if pressure levels in the underlying aquifer are sufficiently high. Classification of materials from the descriptions usually found in well logs is difficult; however, in logs where descriptions of materials are more precise and presumably of greater reliability, the sand content is greater than has been generally assumed. Consequently, the aquiclude is believed to have a somewhat greater, though still restricted, permeability than has been supposed in the past.

That portion of the aquiclude of Recent age has not been appreciably faulted or folded; however, the portion of late Pleistocene age has been affected to some extent by tectonic movements.

The thickness of the Bellflower aquiclude, as shown on Plate 9, varies from zero to 200 feet. The areas of greatest thickness occur along the center and east flank of the Gardena Syncline in the West Coast Basin. Other areas of considerable thickness, ranging up to 140 feet, are generally aligned with the South Gate-Santa Ana Depression.

Gaspur Aquifer. The basal coarse phase of the Recent series has been referred to in previous reports as the Gaspur water-bearing zone. These sediments were described by Poland, et al (1956) and in California D.W.R. 1952a and 1952b. The term "aquifer" is used in this report rather than "water-bearing zone", the expression previously employed, as being more descriptive of the function of the deposits. According to Poland, et al (1956) the name of the aquifer is derived from the identification of a typical section in the log of a well near Gaspur Station at the coastal end of Dominguez Gap.

The extent of the Gaspur aquifer is shown on Plate 10, entitled "Lines of Equal Elevation on the Base of the Gaspur, Ballona, Artesia, and Exposition Aquifers". Its westerly arm, extending southerly from the Los Angeles Narrows, joins the easterly arm extending southwesterly from the Whittier Narrows near Downey and continues southwesterly through Dominguez Gap to the ocean. Throughout the 23 mile length of the aquifer the width varies from one to five and a half miles.

The type cobbles and pebbles in the Gaspur aquifer indicate that they are derived from the San Gabriel Mountains and other highland areas surrounding the San Gabriel and San Fernando Valleys.

The continental stream deposits found in the Gaspur aquifer range in size from boulder gravel to silt and clay. In vertical section, the upper part is medium to coarse-textured sand while the lower part consists of sand, gravel, and cobbles as large as four or five inches in diameter. There is also a lateral variation in lithology. Well logs north of Rosecrans Boulevard generally show 80 to 90 percent coarse sands and gravels with 10 to 20 percent finer-grained materials. South of Rosecrans Boulevard, about 40 to 50 percent of the sediments comprising the Gaspur aquifer are fine-grained. The fine-grained patches are discontinuous within the Whittier Narrows, and occur as stringers, or elongated lenses. Variations in the thickness and width of the Gaspur aquifer seem to indicate that the stream or streams responsible for original deposition were meandering, braiding, eroding and aggrading. The absence of fine deposits in the lower portion suggests that they were removed by erosion during flood stages. Thickness of the Gaspur aquifer ranging up to about 120 feet, is delineated on Plate 11 entitled, "Lines of Equal Thickness of the Gaspur, Ballona, Artesia, and Exposition Aquifers".

The Gaspur aquifer is merged with surface deposits in the Montebello Forebay between the Rio Hondo and San Gabriel River, extending as far south as Slauson Avenue. It also crops out in the Los Angeles Narrows in an area bounded by the Los Angeles River and the Harbor Freeway, and extends from the Narrows as far south as Firestone Boulevard. These two outcrops areas are shown on Plate 10A.

The gradient of the base of the westerly arm of the Gaspur aquifer is 44.5 feet per mile (a 300-foot drop in elevation in 6.75 miles). The gradient of the base of the Gaspur aquifer along the easterly arm is about 19 feet per mile (a drop of 200 feet in 10.5 miles). Between San Pedro Bay and the point where the two arms of the Gaspur aquifer join, the gradient is 10 feet per mile (a 60-foot drop in elevation in 6.0 miles). The steepness of the westerly arm may indicate uplift to the north and west, although greater rock hardness in Los Angeles Narrows and/or a difference in stream flow regimen caused by changing debris loads also may have caused this steep gradient. Minor warping of both the aquifer and overlying Recent deposits has probably occurred within the Whittier Narrows and Dominguez Gap. The Gaspur aquifer has apparently not been affected by faulting.

Water levels and well histories indicate that the Gaspur aquifer has been partially dewatered. The majority of new wells drilled in the area under which this aquifer lies do not depend solely on this aquifer but are usually drilled into and perforated in deeper aquifers as well. Many existing wells, however, depend only on this aquifer for their supply, and in these wells the yields are usually high. Permeabilities in this aquifer range up to 6000 gallons per day per square foot. (See Table D in Attachment 2 for general values of permeabilities used in the coastal plain).

The Gaspur aquifer is merged with the deeper aquifers in the area immediately south of Los Angeles Narrows, which at one time served as a recharge area. However, this area is now completely covered by buildings and paved streets. Little, if any, direct percolation of water is possible; even the channel of the Los Angeles River is now lined where it passes through this area.

In the vicinity of Whittier Narrows, the deeper aquifers are also merged with the Gaspur aquifer and receive their natural recharge waters through it. Because percolation in the Los Angeles Narrows has been rendered infeasible, the Whittier Narrows is the most suitable remaining location for artificial recharge of the underlying aquifers. Consequently, the principal recharge basins and projects for recharging local surface flood waters and imported waters are located in this area, from whence natural percolation processes carry this water into the deeper aquifers.

Ballona Aquifer. The other principal aquifer of Recent age is the Ballona aquifer, which has previously been termed the "50-foot gravel". Poland, et al (1959a) originally assigned the name "50-foot gravel" to the lower divisions of the Recent series in Ballona Gap, because these occurred at an average depth of 50 feet below the surface. Although this aquifer is included within the Recent series it is believed that at least part of it may be of late Pleistocene age.

The Ballona aquifer lies north of the Ballona escarpment and extends inland to a point east of the Overland Avenue fault. The extent of this aquifer is shown on Plate 10. It is composed of coarse sand, rounded to subrounded gravel, and cobbles up to five inches in diameter that are of both granitic and metamorphic origin. Slate pebbles in this aquifer suggest that the Santa Monica Mountains were a possible source of material; on the other hand, granitic rocks and pebbles appear to come from the San Gabriel Mountains. The Los Angeles River has flowed north of the Baldwin Hills and along Ballona Creek channel in historic time, but no attempt has been made to determine the relative contribution to the Ballona aquifer from the two drainage systems.

The Ballona aquifer varies in thickness from less than 10 feet at the coast to 40 feet near Beverly Hills. Thickness of the Ballona aquifer is delineated on Plate 11.

The base of the Ballona aquifer drops from more than 100 feet above sea level beneath the Sawtelle Plain to 60 feet below sea level near the Ballona Escarpment, a gradient of about 40 feet per mile. There is a southward tilt to the base, which corresponds to the southerly dip into West Coast Basin of the San Pedro formation, and may be due to either erosion and depositional processes or to tilting, or possibly both.

Well yields from the Ballona aquifer are highly variable, ranging from 100 to 800 gpm (Poland, et al 1959a). This may be due to the irregularity and discontinuity of its composition and thickness.

Miscellaneous Alluvial Deposits. Other Recent alluvial deposits include beach deposits, playa lake deposits and lagoonal marshland deposits. These have been described more elaborately (Poland, et al 1959a), and are treated only briefly in this report.

Narrow strips of beach deposits, with materials ranging in size from fine sand to cobbles, are found adjacent to wave-cut cliffs along the coastline. They also exist as barrier beaches across the various gaps along the coast. The beach deposits act as a source for wind-blown material for the coastal-dune belt and may also serve as a permeable conduit for sea-water intrusion into aquifers near the surface along the coast.

Playa lake deposits found near the intersection of the Coast Highway and Vermont Avenue, about one mile west of Wilmington, have been deposited in shallow closed depressions. Standing water accumulates in these closed drainage areas after heavy rains. These deposits are usually fine-grained sands, silts, and clays.

Lagoonal marshlands extend along the coastal reaches of the Los Angeles and San Gabriel Rivers and Ballona Creek for a distance of one-half to three miles inland. Deposits in these areas appear to be heterogeneous in nature, lenticular, and mostly fine-grained. These sediments may also include medium sand, silty sand, clay and peat deposits.

Active Dune Sand. Wind-blown sands occur in a narrow strip 0.2 to 0.5 miles inland and parallel to the coast and continue from Ballona Escarpment southward to Redondo Beach for a distance of about nine miles. These deposits are known as the Active Dune Sands. Plate 3B shows the extent of these deposits which are identified by the symbol Qsr. These eolian deposits are lenticular, and composed of fine to medium, white or grayish sand, usually well sorted. These sediments may also include medium sand, silty sand, clay and peat deposits. The Active Dune Sands range up to 70 feet in thickness. Being above the zone of saturation, the sands do not yield water to wells. However, they are relatively permeable and water held in closed depressions after heavy rains does percolate vertically downward and laterally. The dune sands may therefore serve as recharge media to any water bodies that underlie this area.

Pleistocene Series

The Pleistocene series is divided into upper Pleistocene and lower Pleistocene in most of coastal California, primarily because they are separated by an angular unconformity in many uplift areas. Fossils are used as an additional index to separation of the Pleistocene series. The boundary between deposits of Pliocene and Pleistocene age is difficult to determine and consequently is somewhat arbitrary in many areas.

In the coastal plain the upper Pleistocene is represented by the Older Dune Sands and the Lakewood formation, while the lower Pleistocene consists of the San Pedro formation (Poland, et al, 1956). Where they appear on the surface the Older Dune Sands, Lakewood formation, and the San Pedro formation are identified by the symbols Qso, Qlw, and Qsp, respectively. on Plate 3. A small zone of transitional material, cropping out between the San Pedro formation and the underlying Pico formation of Pliocene age is also shown on Plate 3 and identified by the symbol Qsp-Pp.

Older Dune Sand. Dune deposits occur in West Coast Basin which are older than those described under the Recent Series. These wind-blown materials are sufficiently significant in manner of deposition, lithology and topography, to be considered in this report as a separate unit. The term "Older Sand Dunes" has been previously used to designate these wind-blown deposits; however, in this report, the more descriptive term "Older Dune Sand" is used to identify these deposits.

The Older Dune Sand has been described by Poland, (1956, 1959b) and in Calif. D.W.R. 1952a and 1957c. Although these sediments have been previously classed as Recent materials, they are now considered to be of late Pleistocene age.

The Older Dune Sand covers an area three to four miles wide and about 13 miles long extending along the Santa Monica Bay Coast line south of Ballona Escarpment. Surface exposures and well logs indicate that the dune sediments cover the Ocean Park Plain as well as a portion of the West Coast Basin. In the Ballona Creek area the older dunes have been removed. In the West Coast Basin the Older Dune Sand together with the Active Dune Sand form the El Segundo Sand Hills.

The Older Dune Sand consists of fine to medium sand with minor sandy silt, clay, and gravel lenses. Within the weathered zone the materials are yellow to brown in color although the unweathered formation in place is white, gray and black in color. The Older Dune Sand generally consists of three divisions: a deeply weathered surface, an intermediate horizon of clean sands and basal beach sands and gravels, and a lowermost horizon which apparently includes a zone of transition to the underlying Bellflower aquiclude.

Cross-bedding, and fossils in exposures near the Hyperion Sewage Treatment Plant at El Segundo and elsewhere, indicate that the sands were originally beach deposits with associated coarse gravels. These beach deposits were exposed to the wind by lowering of the sea level, resulting in formation of the present Older Dune Sand. Deep weathering has oxidized the iron minerals which, through cementation and leaching processes, have partially filled the interstices between individual grains, thus reducing the permeability of the weathered Older Dune Sand to some extent. Uplifting may have gently tilted these dunes toward the southwest.

Deep percolation of surface water occurs in most of the Older Dune Sand area, especially where closed depressions occur. Directly beneath these older dunes in part of the El Segundo Sand Hills, the fine sediments of the Bellflower aquiclude restrict downward movement of ground water. However, the aquiclude is missing along the ocean and ground water can move laterally into an area where downward percolation can again occur.

Lakewood formation. The Lakewood formation includes all upper Pleistocene deposits other than the Older Dune Sand. It includes what has previously been termed "terrace deposits", "Palos Verdes sand", and "unnamed upper Pleistocene deposits". Other names which have been used for upper Pleistocene deposits or parts of these deposits include the Sunny Hill formation (Hoskins, 1954,), and San Dimas formation (Eckis, 1928). These names, however, are awkward for use in the entire coastal plain since the named formations have been described as existing only in the limited associated area. The present designation was selected from a typical section indicated in the log of a well at Lakewood where this formation reaches a maximum thickness of approximately [illegible] feet.

In the upper part of the Lakewood formation lithologic changes are rapid, with discontinuous permeable zones and considerable variation in particle size. No shell zones have been found in the upper part of this formation. These features represent typical stream type alluviation with flood plain fine-grained sediments comprising from 40 to 80 percent of the total deposits. In the lower horizons the gravels and coarse sands are confined to a narrow belt extending over the Newport-Inglewood uplift. Gravels range from pea-size to cobbles, three to four inches in diameter. Over the balance of the coastal plain, coarse basal deposits of sand and gravel are fairly continuous with discontinuous lenses of sandy silt and clay. The basal part of the Lakewood formation in the Cheviot Hills area of Beverly Hills has been called the Medill sand by Rodda (1957)..

The Lakewood formation extends beneath most of the coastal plain. In portions of the Baldwin Hills, Signal Hill, Palos Verdes Hills, and Coyote Hills, it has been eroded, exposing the underlying San Pedro and older formations. In the La Brea, Santa Monica, and Montebello Plains, and on the flanks of the Palos Verdes Hills and Puente Hills, the Lakewood formation unconformably overlies the lower Pleistocene San Pedro formation, the Pliocene Pico and Repetto formations, and the Miocene Puente formation.

The Lakewood formation is divided into the Artesia-Exposition aquifers, the Gage-Gardena aquifers, and the unnamed aquicludes between the aquifers. In some areas, portions of the Semiperched aquifer and the Bellflower aquiclude, described under Recent alluvium, are included. The base of the Lakewood formation generally coincides with the base of the Gage and Gardena aquifers. The aquifers of the Lakewood formation are discussed in the following paragraphs.

Artesia-Exposition Aquifers. The Artesia and Exposition aquifers, although located in separate geographical areas, are similar in composition and mode of deposition; this leads to the conclusion that they are contemporaneous. They are, therefore, jointly discussed in this section. The Artesia aquifer appears to be related to the San Gabriel River, Coyote Creek, and Santa Ana River systems, and the Exposition aquifer is related to the Los Angeles River drainage system. As shown on geologic section C-C'-C", Plate 6B, these aquifers extend beneath the Gaspur aquifer at which point they merge with each other and with the overlying Gaspur aquifer. On Plates 10 and 11, the contours on the base of the Artesia-Exposition aquifers and lines of equal thickness are not extended beneath the Gaspur aquifer since it is difficult to distinguish the separate aquifers.

The Artesia aquifer extends from the middle of the Santa Fe Springs Plain southward, where it underlies the northern portions of the Bouton Plain, Signal Hill, and Bixby Ranch Hill. It follows the general trend of the present San Gabriel-Coyote Creek drainage as shown on Plate 10. The Artesia aquifer extends southeasterly from the Gaspur aquifer to and beyond the Los Angeles-Orange County line. However, since no study has been made of the extension of this or any other aquifer outside the area of investigation, it is terminated at the county line.

The Artesia aquifer is composed of coarse gravel, coarse to fine sand and interbedded silts and clays. In some areas, individual gravel members within the aquifer can be identified in drillers logs for considerable distances. The Artesia aquifer has a general southwesterly dip, and varies in thickness (Plate 11) and bottom configuration (Plate 10).

The ancestral San Gabriel and Santa Ana Rivers, and Coyote Creek, appear to have been the main source of the sediments comprising this aquifer. The Santa Ana River may have contributed sediments to the southern portion of the area since this river once flowed directly west and joined the San Gabriel River near its present confluence with Coyote Creek.

The geographical extent of the Exposition aquifer is shown on Plate 10. This aquifer consists of one to four discontinuous coarse members. Materials range in size from coarse gravels to clay, with the fine deposits separating the lenticular sandy and gravelly beds. Changes in lithology are frequent as evidenced by the many lenses of silt and clay encountered in the drillers logs.

Deposition of this material appears to have been controlled by the ancestral Los Angeles River, which may have flowed through the Silver Lake area (Riveroll, 1957) in the geologic past, as well as by tributary streams from the Santa Monica Mountains, Elysian Hills, and Repetto Hills. The configuration of the base of the Exposition aquifer, as well as the Artesia aquifer, is highly irregular and it appears that both were deposited on an erosional surface. A study of well logs indicates that the upper coarse members of the Exposition aquifer were either eroded and backfilled by Gaspur deposits or that some of the upper members were deposited contemporaneously with the formation of the Gaspur aquifer. Highway excavations in the vicinity of Boyle Heights and other areas along the south slope of the Repetto Hills and along the east bank of the Los Angeles River have exposed clean sands and gravels which are apparently an upper member of the Exposition aquifer.

The maximum thickness of the Exposition aquifer is 100 feet. Lines of equal thickness of the aquifer, including interbedded fine materials as well as the permeable zones, are shown on Plate 11.

Stratigraphically, the Artesia and Exposition aquifers lie above the Gage aquifer, described subsequently, and are generally deeper than the Gaspur aquifer, although some of the upper coarse members abut directly into the Gaspur aquifer and may be of the same age. At Boyle Heights and other places, the Artesia and Exposition aquifer have been uplifted and are now higher in elevation than the adjacent Gaspur aquifer. Lower members of the Exposition continue beneath the Gaspur aquifer and merge laterally with the Artesia aquifer. The Exposition aquifer merges with the underlying Gage aquifer approximately three miles northwest of downtown Los Angeles and also in the triangular area between the easterly and westerly arms of the Gaspur aquifer on the Montebello Plain,as shown on Plate 12, "Lines of Equal Elevation on the Base of the Gage and Gardena Aquifers".

The Potrero fault is the only known structure that displaces the Exposition aquifer. However, both the Artesia and Exposition aquifers have been affected by folding and show slight warping near the Newport-Inglewood uplift and in the downwarped area of the Central Basin.

Gage Aquifer. The basal or lowest member of the Lakewood formation is termed the Gage aquifer. The name "200-foot sand" was applied to this aquifer by Poland, et al (1948 and 1959a), later by Richter (1950) and in the "Report of Referee", (Calif. D.W.R. 1952a). Originally the designation of the "200-foot sand" was used because the aquifer occurred about 200 feet below land surface in the syncline extending from Inglewood southeasterly through Gardena. In the Central Basin the base of the aquifer varies from 100 to over 350 feet below the surface; consequently the term "200-foot sand" is inapplicable. The lowest elevation this aquifer attains is in the vicinity of Lynwood, where an elevation of 350 feet below sea level occurs. The Gage aquifer extends over most of the Coastal Plain of Los Angeles County, although insufficient data is available to verify its extension beneath the Santa Monica Plain. Contours on the base of the aquifer are shown on Plate 12.

The composition of the Gage aquifer varies from a fine to medium sand with variable amounts of gravel, sandy silt, and clay in the West Coast Basin, to a coarse yellow sand and minor gravel (two to four inches in diameter) in the center of the Central Basin, and to a fine yellow sand and gravel toward the Whittier Narrows region. The thickness varies from 10 feet to a maximum of 160 feet in the Torrance area. The thickness of the aquifer is shown on Plate 13, "Lines of Equal Thickness of the Gage and Gardena Aquifers".

Deposits that comprise this aquifer are of both marine and continental origin. Along the northerly boundary of the Central Basin, that is, along the base of the Santa Monica Mountains and the Elysian and Repetto Hills, the deposits appear to be continental in origin. In the southeastern half of the coastal plain the aquifer consists mainly of mixed continental and marine, or in some areas, solely marine sediments.

Subsurface structures which either cut the aquifer or against which the aquifer terminates are shown on Plate 12. Areas where the aquifer is merged with overlying aquifers are also shown on this plate.

While this aquifer generally consists of sand, wells have been perforated in it only in areas where coarser materials exist. Approximately 200 wells have been drilled into the Gage aquifer in the West Coast Basin in the vicinity of Gardena but it is unimportant as a producing aquifer in other areas.

Gardena Aquifer. In 1950 Richter described the coarse deposits comprising this aquifer within the West Coast Basin under the term "Gardena Water-bearing Zone". In "Report of Referee" (Calif. D.W.R. 1952a) the description of the Gardena Water-bearing Zone was further elaborated. In the present investigation the extent of the Gardena water-bearing zone in the Central Basin was determined and these deposits have been designated the "Gardena aquifer". This term now applies to all of the coarse deposits that are contemporaneous with the Gage aquifer (fine grained deposits) in both the Central and West Coast Basins.

The Gardena aquifer extends inland from Redondo Beach beneath the City of Gardena, across the Newport-Inglewood uplift and into the Central Basin, where it loses its identity near Lynwood. Further inland, identical coarse deposits are again discernible underlying the Montebello Plain and within the Whittier Narrows. These two areas, however, are separated by the Gage aquifer which underlies that part of the Central Basin where the water-bearing deposits are deepest. In the western part of the coastal plain, the deposits form a strip one to four and one-half miles wide extending from Lynwood to the coast. Other coarse deposits, believed to be at the same stratigraphic horizon, extend southwesterly from the Whittier Narrows and then form two southeasterly trending lobes. One lobe reaches the area south of downtown Los Angeles and the Elysian Hills, and the other extends along the south side of the Santa Fe Springs Plain to the vicinity of Norwalk. The extent of these deposits is shown on Plate 12.

The lithology of the Gardena aquifer in the West Coast Basin is given by Richter (1950) as coarse sand and gravel with discontinuous lenses of sandy silt and yellow to blue clay, with the gravel sizes ranging from pea-size to cobbles three to four inches in diameter and the sand ranging from fine to coarse. Deposits in the Central Basin also contain coarse sands and gravels, with minor lenses of sand, silty clay, and clay. The deposits are similar in thickness and elevation to those of the Gage aquifer and are in direct continuity with the Gage materials. According to Richter (1950), the thickness within the West Coast Basin varies from 50 to 75 feet between the Avalon-Compton fault and the City of Gardena; from 75 to 100 feet west of Gardena, and is over 100 feet where it overlaps the merged Lynwood and Silverado aquifers near the coast. The present study indicates that the Gardena aquifer varies in thickness from 40 feet near Lynwood to 100 feet near Gardena and increases to 160 feet northwest of Torrance. Lines of equal thickness are shown on Plate 13.

As shown on Plate 12, the lowest elevation of the base of this aquifer is 350 feet below sea level in the Central Basin and 200 feet below sea level in the West Coast Basin. On the Newport-Inglewood uplift, as well as in the merged area near the coast, the elevation of the base is 100 feet below sea level.

Richter (1950) indicated that this aquifer was one of fluvial origin since the alignment over the Newport-Inglewood uplift was narrow and perpendicular to probable ancient shore lines; furthermore, these deposits are similar to other Recent alluvial deposits in Dominguez and other Gaps. However, Poland (1959a) suggested that this coarse deposit may have been laid down beyond a shore line fringing the Newport-Inglewood uplift. Work in conjunction with this investigation, however, leads to the same conclusion outlined by Richter.

Some ancestral river flowing southwesterly incised a channel across the Newport-Inglewood uplift and eroded away most of the sediments comprising the Gage aquifer ("200-foot sand"). In this channel coarse fluvial deposits were laid down during a subsequent rise of sea level. Coastward from the uplift some shells have been found in wells drilled in this aquifer suggesting that fluvial action may have been affected by shallow lagoons or estuaries. From further study conducted during this investigation, it appears that the Rio Hondo-San Gabriel River systems have been the principal transporting agencies for sediments comprising the Gardena aquifer. However, because the two inland lobes of the Gardena aquifer extend parallel to the inland foothills there is a possibility that the Los Angeles River may have deposited portions of it.

In the Whittier Narrows, the Gardena aquifer is cut by the Rio Hondo fault shown on Plate 7, and it has been folded up to 11 degrees along the edge of the area near Boyle Heights. Recent uplift along the crest of the Rosecrans anticline has arched the Gardena aquifer, and this is shown on Plate 12 by contours plotted of the base of the aquifer.

The Gardena aquifer has yielded large quantities of water to wells. Because of its coarse texture and continuity, it is an important aquifer in the coastal plain. It is in hydraulic continuity with the Gage aquifer throughout most of its extent and for this reason the isopachs (lines of equal thickness) and elevation contours are plotted on the same maps as the Gage aquifer.

San Pedro Formation. The San Pedro formation has previously been defined to Poland, et al (1945, 1948, 1956, 1959a), as "that stratigraphic unit underlying the unnamed upper Pleistocene deposits and overlying the Pico formation of the late Pliocene age..... Essentially, the San Pedro formation embraces all strata of lower Pleistocene age." Richter (1950) defined the San Pedro formation as "all of the deposits of lower Pleistocene age which underlie West Basin." The original type section of the San Pedro formation contained San Pedro sand, Timms Point silt, and Lomita marl; however, Poland has stated that the San Pedro formation "includes some strata that are younger and may include some that are older than any exposed in the type section cited."

Eckis, (Calif. D.W.R., 1934) used the term "Fernando Group" for the lower Pleistocene and upper Pliocene strata that occurs along the inland foothills of the coastal plain. Since this term included the upper Pliocene deposits, not considered important fresh-water-bearing sediments, the designation "San Pedro formation" is used in this report for the heterogeneous materials comprising the lower Pleistocene horizons.

The San Pedro formation underlies most, if not all, of the Coastal Plain of Los Angeles County as well as portions of the Santa Monica and San Pedro shelves offshore. In the type section along the north flank of the Palos Verdes Hills the San Pedro formation is composed of stratified sand with some beds of fine gravel, silty sand, and silt. Crossbedding occurs frequently in the outcrop. Some pebbles of limestone, siliceous Miocene shales and schist are also found. Away from the Palos Verdes Hills the percentage of granitic fragments increase. In 1950, Richter described the lithology of the San Pedro formation as it occurs in West Coast Basin as "gray sand, which weathers brown or reddish brown on exposure, and interbeds of small gravel are characteristic. Sand and gravel fragments are mainly granitic, indicating a common source area, probably the San Gabriel Mountains". Fine-grained members are generally marine type, blue to black clays, sea muds, or quicksand with abundant shells. The Anchor silt found in the Cheviot Hills (Rodda, 1957) is one of these members. It is correlative with the Timms Point silt, of lower Pleistocene age, and to the lower part of the San Pedro formation. The Coyote silt found in the Coyote Hills (Hoskins, 1954) is also of lower Pleistocene age and resembles the Anchor silt.

The thickness of the San Pedro formation is about 1050 feet beneath the Downey Plain along the South Gate-Santa Ana Depression, and increases to a maximum of 1350 feet in the area about two miles east and southeast of Norwalk along the Norwalk synclinal axis. Where section C-C'-C" (Plate 6b) crosses the Rosecrans anticline, the thickness is 570 feet. Within the West Coast Basin the thickness is greatest along the Gardena syncline, varying from 400 feet about 1 1/2 miles west of Inglewood to 500 feet 1 mile north of Hawthorne, 700 feet at Gardena, and to as much as 1050 feet near the intersection of Carson and Alameda Streets.

The San Pedro formation crops out along the south side of the Repetto, Merced, and Puente Hills; on the Coyote Hills, Baldwin Hills, and Beverly Hills; along the north side of the Palos Verdes Hills; and on Signal Hill. Around the margins of the coastal plain, the San Pedro formation is upturned, and in some local areas is beveled and capped by younger strata.

Most of the structures encountered within the area of study affect at least part of the San Pedro formation. Elevation contour maps on the bases of the aquifers that comprise this formation indicate which fault or faults displace the aquifers. Much folding and warping, along with erosion, also has affected many of the aquifers. The structures affecting the San Pedro formation will be discussed in the descriptions of individual aquifers to follow.

On Plate 3 the San Pedro formation, where it appears at the ground surface, is represented by the symbol "Qsp". Although the formation is shown as one unit for convenience, it has been divided into various stratigraphic units or members. Only those members capable of storing or conveying ground water in suitable quantities have been named as aquifers, while the intervening finer-grained zones were not named. In downward succession, excluding the fine-grained interbedded layers, the aquifers are: The Hollydale aquifer, the Jefferson aquifer, the Lynwood aquifer ("400-foot gravel"), the Silverado aquifer, and the Sunnyside aquifer. Since most of the important aquifers used for production within the coastal plain are contained within the San Pedro formation, their complex water-bearing characteristics are discussed in Chapter VI rather than in the following description.

Hollydale Aquifer. The uppermost aquifer within the San Pedro formation is named the Hollydale aquifer. Although discontinuous in extent, it reaches from the Newport-Inglewood uplift north and northeastward to the south line of the Elysian, Repetto, Merced, and Puente Hills, and eastward and southeastward to and beyond the Los Angeles-Orange County line. Plate 14, entitled "Lines of Equal Elevation on the Base of the Hollydale Aquifer", shows the sinuous irregular courses of this aquifer.

The lithology of this aquifer is variable and consists of yellow sands and gravels (pea-size to two inches) in the northeastern portion of the area, while grey, blue, and black sands, with muds, clays, and marine shells become more predominant toward the Newport-Inglewood uplift. Well log reports are the only means of determining the lithology for this aquifer because it does not crop out on the surface. The well logs indicate that some of the marine sands are mushy, while others are cemented and hard.

The irregular, sinuous, and meander-like courses of the aquifer suggests a stream deposition, but the lithology of the aquifer over three-fourths of the area indicates shallow marine deposition. Because the two main lobes of the aquifer open toward the Los Angeles and Whittier Narrows, it is assumed that streams flowing through these two narrows have controlled the deposition of those parts, while a part of the sediments were laid down beneath shallow water in lagoons or estuaries.

Lines of equal thickness of this aquifer are shown on Plate 15, "Lines of Equal Thickness of the Hollydale Aquifer". The thickness varies from less than 10 feet to a maximum of 100 feet near Lakewood.

In stratigraphic position the Hollydale aquifer is the first important aquifer beneath the Gage-Gardena aquifers. The Hollydale aquifer is overlain and underlain, in most areas, by fine-grained members or aquicludes of the San Pedro formation. Elevation contours on the base of the Hollydale aquifer and areas of mergence with overlying aquifers are shown on Plate 14. The aquifer attains its greatest depth at an elevation of 500 feet below sea level about two miles east of Compton. In the area between the towns of Norwalk and Bellflower, the depth is about 450 feet below sea level. The slope of the base of the Hollydale aquifer is generally toward these two areas of greatest depth.

Upfolding along the Newport-Inglewood uplift has apparently limited the depositional area of the Hollydale aquifer to the Central Basin. Within the Central Basin the aquifer does not exist in upfolded areas. Downfolding along the axis of the Paramount and Norwalk synclines has, however, placed the base of the aquifer at an elevation of 500 feet below sea level.

This aquifer apparently does not yield large quantities of water to wells, therefore few wells are perforated in this interval and even then only when producing horizons above and below are also perforated. Low productivity of the Hollydale aquifer may be due to the fineness of the materials of which it is composed and the lack of continuity in its extent.

Recharge of the Hollydale aquifer can be accomplished only where it merges with the overlying Gage or younger aquifers (Plate 14) because of the absence of outcrop areas.

Jefferson aquifer. Within the Central Basin, the second aquifer in downward succession within the San Pedro formation is designated the Jefferson aquifer. This aquifer extends over most of the Central Basin, although it is not known to reach the surface. Lobes of this aquifer extend into the Whittier Narrows, into the La Brea Plain, and south of the Coyote Hills through Buena Park into Orange County. Within the boundaries of the aquifer, some irregular areas exist where the aquifer has not been identified, as indicated on Plate 16, "Lines of Equal Elevation on the Base of the Jefferson Aquifer". This aquifer has not been located in the West Coast Basin. The Jefferson aquifer occurs in sinous courses extending from both the Los Angeles and Whittier Narrows into Orange County.

The lithology of the Jefferson aquifer is known only from drillers logs of water wells. The sediments comprising this aquifer are, for the greater part, fine-grained. Gravels are most extensive in the Whittier Narrows but also occur in scattered patches through the rest of the Central Basin. The remainder of the aquifer consists primarily of sand with some gravelly and clayey lenses.

From the pattern of distribution of sediments comprising this aquifer, source areas are assumed to have been the San Fernando and San Gabriel Valleys and their surrounding highlands. The Los Angeles and San Gabriel Rivers appear to have transported the material through the Los Angeles and Whittier Narrows into or through three possible areas: the La Habra Piedmont slope, the Buena Park area, and southward toward Seal Beach. Extensions of these areas into Orange County have not been determined.

The thickness of the Jefferson aquifer is shown on Plate 17, "Lines of Equal Thickness of the Jefferson Aquifer", and varies from a few feet to a maximum of 140 feet along the Los Alamitos fault. At Norwalk the Jefferson aquifer is 120 feet thick. The Jefferson aquifer has been considerably folded and its base varies in elevation from 700 feet below sea level to 50 feet above sea level.

Structures that affect the Jefferson aquifer are the Los Alamitos, Rio Hondo, Pico, and Cherry Hill faults, and possibly the Seal Beach fault.

It is believed that the general upwarped area along the Newport-Inglewood uplift has controlled or confined to the Central Basin the deposition of sediments comprising this aquifer.

Although it does not crop out on the surface, the Jefferson aquifer does merge with the overlying Hollydale aquifer and also with the Gage aquifer along the Elysian Hills, Repetto Hills, and within the Whittier Narrows. These areas of mergence are shown on Plate 16.

Artificial recharge within the Whittier Narrows would have some effect on this aquifer. Since less than 10 percent of the wells in the Central Basin are perforated in this horizon, and then only in areas where coarse sandy and gravelly zones are found, it is not considered an important water producing aquifer.

Lynwood Aquifer. The Lynwood aquifer is the term used for the third aquifer in stratigraphic sequence within the San Pedro formation. The term "400-foot gravel" has been applied to this aquifer in the West Coast Basin. This latter term was first used by Poland (1948) and defined as "a distinct water-bearing zone in the upper part of the San Pedro formation .... its base is about 400 feet below land surface along the axis of the syncline" (southwest of the Newport-Inglewood uplift). Plate 18, "Lines of Equal Elevation on the Base of the Lynwood Aquifer", and Plate 19, "Lines of Equal Thickness of the Lynwood Aquifer" show the extent, elevation of the base, and thickness of this aquifer.

The Lynwood aquifer extends throughout the Central and West Coast Basins and its existence has been verified in the Hollywood Basin. There is no evidence to show that it exists in the Santa Monica Basin, nor has it been identified in the Baldwin Hills.

Materials of which the Lynwood aquifer is composed appear to be both continental and marine in origin. Continental deposits, of yellow, brown, and red coarse gravels, sands, silts, and clays, are found in the vicinity of the Montebello Forebay Area. A line bounding this area extends from the Whittier Narrows to Bellflower, thence to Compton, South Gate, Huntington Park, and back to the Whittier Narrows. One arm of continental sediments extends from the area just described toward Hawthorne. Sediments of the Lynwood aquifer surrounding the Montebello Forebay Area are mostly marine deposits and are characterized by sand and gravel and blue, grey, and black silts and clays. Some of the sands and gravels have been cemented. The several areas where the marine deposits consist predominantly of fine-grained materials vary from less than 100 acres to about six or seven square miles in extent, and are shown on Plate 19.

From the study of well logs and the materials from wells drilled into this aquifer, it appears that the Rio Hondo and San Gabriel River systems have been the major contributing source for the continental sediments. Marine-type deposits appear to have been laid down when the area was covered by shallow seas.

The Lynwood aquifer ranges from less than 50 feet to about 200 feet in thickness near Wilmington, as shown on Plate 19. Near Lakewood, Torrance, Inglewood, and Montebello it is about 150 feet in thickness. The base contours and lines of equal thickness are not shown west of the Gardena syncline because of mergence with the Silverado aquifer.

In stratigraphic sequence the Lynwood aquifer is overlain and underlain in most of the area by fine-grained materials such as clays, silts, and sandy and silty clays. It is beneath the Jefferson aquifer and above the Silverado aquifer. Known areas of mergence with the overlying aquifers are shown on Plate 18, while the areas of mergence with the Silverado aquifer are shown on Plate 20, "Lines of Equal Elevation on the Base of the Silverado Aquifer".

Folding has been the primary structural factor affecting the Lynwood aquifer. Upfolding or upwarping has occurred along the coast in the West Coast Basin, over the Newport-Inglewood uplift, in the Artesia area over the Santa Fe Springs uplift, along the edge of the Elysian, Repetto, and Puente Hills, and within the Whittier Narrows. Downwarping has affected the aquifer in the Hawthorne-Long Beach depression extending to San Pedro, within the South Gate-Santa Ana depression (includes Paramount and Norwalk synclines), and within the La Habra syncline. Within the West Coast Basin the Charnock fault has offset the Lynwood aquifer. Along the Newport-Inglewood uplift, the Inglewood, Potrero, Avalon-Compton, Cherry Hill, Northeast Flank, and other associated transverse faults cut the aquifer. Within the Central Basin the Los Alamitos fault offsets the Lynwood aquifer as does the Rio Hondo and Pico faults within and south of Whittier Narrows.

The Lynwood aquifer is an important producer of ground water and is discussed in more detail in the descriptions of the ground water basins in Chapter VI. Most wells in the coastal plain drilled to or below this aquifer are perforated in it. Yields of wells perforated only in the Lynwood aquifer vary from 200 to 2100 gallons per minute.

Surface and subsurface flow of water through the Whittier Narrows moves downward through the shallow aquifers into the Lynwood aquifer. Water is also artificially spread in shallow pits below the Whittier Narrows where the Lynwood aquifer is in contact with the permeable materials extending upward into the pits, thus permitting this water to reach the Lynwood aquifer. This artificial method of recharging is not generally applicable in other areas where the Lynwood aquifer is merged with the overlying aquifers because of the greater depth of those aquifers as well as the Lynwood aquifer below the surface, the lack of continuous permeable materials to conduct water vertically downward, and the lack of available space for large surface pits. In these areas, therefore, other methods of recharge would be necessary, such as injection wells drilled into and perforated in this aquifer.

Silverado Aquifer. The Silverado aquifer is the name applied in this report to those water-bearing materials which are stratigraphic equivalents of the "Silverado Water-Bearing Zone" in the West Coast Basin. Originally named by Poland, et al (1956), from its typical occurrence in a well in Silverado Park, Long Beach, the Silverado Water-Bearing Zone has been found throughout the rest of the Coastal Plain of Los Angeles County and extends across the Los Angeles County line into Orange County. For the purpose of this report the term, "Silverado aquifer", will apply to these materials throughout the Coastal Plain of Los Angeles County. Areas of Pleistocene deposits occurring in the Santa Monica and San Pedro shelves offshore may be continuations of the Silverado and underlying Sunnywide aquifers. Plate 20 shows the known extent and elevation contours of the base of the Silverado aquifer.

Sediments comprising the Silverado aquifer are both continental and marine. Where continental deposits predominate, yellow to brown, coarse to fine sands and gravels are interbedded with yellow to brown silts and clays. Marine deposits which comprise the Silverado aquifer over the remainder of the basin are primarily blue to grey sand, gravel, silt, and clay. Some black sands, quicksand, marine shells, peat, and wood fragments are also shown on drillers logs of wells located in the area of marine sediments. In the West Coast Basin, Richter (1950) describes the lithology as fine to coarse, blue-black arkosic sand with the larger grains composed of granite, granodiorite, and diorite. Along the flanks of the Palos Verdes Hills, limestone and schist pebbles are abundant, while in the Ballona Gap area slate, schist, and volcanic pebbles are commonly found.

The ancestral Rio Hondo and San Gabriel River systems have been the major transporting agent for materials comprising the continental portion of the Silverado aquifer in Central Basin, although some contributions may have been added by the Santa Ana River flowing in one of its earlier courses. The regional evidence indicates that the Los Angeles River did not flow into the coastal plain during much of the lower Pleistocene time and probably did not contribute sediment to the Silverado aquifer. However, streams flowing from the Santa Monica Mountains, Elysian Hills, and Palos Verdes Hills have added debris from these areas. Much of this material was deposited beneath the shallow ocean that covered the coastal plain at this time. The continental deposits appear to have been laid down when the sea was retreating from the coastal plain.

The varying thickness of the Silverado aquifer is depicted on Plate 21, "Lines of Equal Thickness of the Silverado Aquifer". This aquifer reaches a maximum thickness of 500 feet between the Wilmington anticline and the Cherry Hill fault. One mile west of Lakewood, along Carson Street, the Silverado aquifer is 450 feet thick. Along the south side of the Santa Fe Springs Plain and also two miles southeast of Huntington Park it is 300 feet thick.

The maximum depth reached by the base of the Silverado aquifer, 1200 feet below sea level, is found southwest of the Cherry Hill fault within Dominguez Gap, along the north side of the Los Alamitos fault, and about three miles southeast of Norwalk. A depth of 1100 feet below sea level occurs near Long Beach Harbor.

The Silverado aquifer crops out along the northeast flank of the Palos Verdes Hills, possibly on the continental shelf beneath Santa Monica Bay, along the southern margin of the Baldwin Hills, in the Repetto and Merced Hills, along the south slope of the Puente Hills, and possibly in the Coyote Hills. Outcrops in the areas named are shown as the San Pedro formation, Qsp on Plate 3, because insufficient data are available to definitely identify the aquifer involved.

Areas where the Silverado aquifer merges with overlying aquifers are shown on Plate 20. In the Montebello Forebay Area and Whittier Narrows the Silverado aquifer is directly overlain by and merges with aquifers younger than the Lynwood aquifer. Merged areas are irregular in extent but are generally found along the Newport-Inglewood uplift, in the area from Huntington Park to Santa Fe Springs, and also within the Whittier Narrows. In the West Coast Basin the Silverado is merged with the overlying Lynwood aquifer everywhere except beneath the Gardena syncline and the Wilmington anticline. Near Santa Monica Bay the Silverado aquifer is in hydraulic continuity with the Gardena and Gage, as well as the Lynwood aquifers. In the Montebello Forebay Area the Silverado aquifer merges with the overlying Lynwood, Jefferson, Hollydale and Gardena aquifers, as delineated on Plate 20A.

The Silverado aquifer has suffered a greater degree of folding than the overlying Lynwood aquifer. It has been deformed by all of the major anticlinal and synclinal folds. All the major faults shown on Plate 3 seem to have affected this aquifer. After faulting occurred, the aquifer may be found at either different or the same elevation but separated by a region of altered permeability. Sufficient data is lacking to determine whether the geologic structure just south of Santa Fe Springs is a fault or downfold. On the basis of the data available it is believed that the postulation of a sharp downfold would explain the existing structure in a more adequate manner than the assumption of a fault.

This aquifer is one of the most important ground water producers in the coastal plain. Specific capacities of wells perforated in it range up to a maximum of 159 gallons per minute per foot of drawdown and yields range up to 4700 gallons per minute.

In the Whittier Narrows the Silverado aquifer is merged with many overlying aquifers and recharging the shallow aquifers in that area would cause additional water to reach the Silverado aquifer. Recharge from the surface in the Los Angeles Forebay Area may also reach the Silverado aquifer where it is truncated by the Gaspur. Other possible recharge areas for the Silverado aquifer are in the outcrop along the Coyote and Baldwin Hills, or in the Ballona Gap, where the Silverado aquifer is directly beneath the Ballona aquifer and close to the surface. Natural recharge takes place in those areas shown on Plate 3 where the San Pedro formation crops out on the surface.

Sunnyside Aquifer. The water-bearing materials occurring within the Central Basin beneath the Silverado aquifer but above the Pico formation have been termed the "Sunnyside aquifer" after a typical occurrence illustrated by the log of a well located in Sunnyside Cemetery in North Long Beach.

The Sunnywide aquifer extends throughout the Central Basin. Its extent and elevation of its base are shown on Plate 22, "Lines of Equal

Elevation on the Base of the Sunnyside Aquifer". Recent drilling along the coastal region from Palos Verdes Hills to Ballona Escarpment has revealed a zone of coarse deposits approximately 500 feet thick occurring beneath the Silverado aquifer, but separated from it by silts and clays. These coarse materials are similar to the Sunnyside aquifer in the Central Basin and may be the extension of the Sunnyside aquifer in the West Coast Basin.

The materials comprising this aquifer are coarse-grained sands and gravels separated by fine-grained interbeds of sandy clay and clay. The lithology shown on a typical well log near the intersection of Del Amo and Cherry Streets is compacted blue sand, coarse blue gravel (up to four inches in diameter), hard blue sandy clay, and clay. Toward the Los Angeles-Orange County line, mushy blue sands and coarse gravels with greater amounts of blue clay are found. At Spring Street and Bloomfield Avenue, well logs indicated that instead of clay, fine blue sand with minor clay streaks was present. Along the center of the coastal plain, about one mile north of Manchester and near Alameda Avenue, fine to medium gravel (one quarter to one inch in diameter), and partly cemented blue clay, and grey to brown shale are typical materials. In Whittier Narrows hard grey sands and gravels, boulders, and blue sandy shale are present.

From drillers descriptions of materials, it is believed that the aquifer is of marine origin and has been affected very little by weathering. Many well logs show marine shells included with the sediments in addition to the interbedded marine-type clays and shales.

The Sunnyside aquifer attains its maximum known thickness of about 300 feet about one to one and a half miles southeast of Maywood in the vicinity of Slauson Avenue and the Long Beach Freeway. Plate 23, "Lines of Equal Thickness of the Sunnyside Aquifer", gives the thickness of the

Sunnyside aquifer. No data is available to determine thickness in the central downfolded area because none of the water wells have reached the aquifer in this area.

It is not definitely known whether the Sunnyside aquifer crops out in any particular location within the Central Basin; however, it is assumed that some of the outcrop areas shown as the San Pedro formation on Plate 3 include the Sunnyside aquifer also. The most likely areas for this to occur are along the south slope of the Repetto, Merced, and Puente Hills, and especially on the top of the Coyote Hills.

In stratigraphic position the Sunnyside aquifer is overlain by the fine-grained Timms Point silt and Lomita marl and underlain by the Pico formation. It may be correlated in age with the unit mapped by Hoskins (1954) as the Coyote silt, the Anchor silt of Rodda (1957), and the La Habra conglomerate of Eckis (Calif. D.W.R., 1934).

Structurally, the Sunnyside aquifer is offset by most, if not all, of the faults within the Central Basin. Some of the faults appear to act as boundaries for the aquifer. Northeast of the Los Alamitos fault the base of the Sunnyside aquifer occurs at a maximum depth of about 1500 feet below sea level.

The Sunnyside merges with the Silverado and other overlying aquifers in many areas delineated on Plate 22, "Lines of Equal Elevation on the Base of the Sunnyside Aquifer". In these merged areas hydraulic continuity is possible through a series of aquifers to the surface. The only known areas where this aquifer may be recharged are limited to outcrops of the San Pedro formation and merged areas where folds have lifted the Sunnyside aquifer near the surface of the ground.

Yields of wells perforated in this aquifer range up to 1500 gallons per minute. Specific capacities of known wells using only this aquifer for production are only fair, ranging from 6 to 25 gallons per minute per foot of drawdown.

Undifferentiated Plio-Pleistocene Sediments

An area of sediments of either Pliocene or Pleistocene age, or possibly both, is shown on Plate 3 in the Repetto Hills southeasterly of Monterey Park. In the geologic literature these sediments have been classified variously as both Pliocene and Pleistocene. Although various fossils are present, age designation based upon them is uncertain. While these sediments are somewhat permeable they have relatively little significance as far as ground water in the coastal plain is concerned; therefore, no attempt was made to determine their age.

These undifferentiated sediments consist of thin bedded to massive silts, sands, and gravels that are locally well indurated and contain limited marine fossil remains. The sediments have been folded and many minor faults and fractures are seen in outcrops.

Although these sediments are considered to be relatively unimportant as far as ground water is concerned, a drainage well constructed in 1959 reportedly yields fair quantities of good quality water. Firm conclusions, however, cannot be drawn from this limited experience.

Tertiary System

Aquifers have not been differentiated in sediments and rocks older than Pleistocene age because of limited well log data. Few wells extend into these materials and little ground water of suitable quality is extracted from them. Some fresh water is now being extracted from the upper member of the Pico formation, discussed first in this section. For pre-Pleistocene materials in general, the sediments and rocks are described by formations or broad age classification.

Pliocene Series

The Pliocene series is divided into two formations, the Pico formation and the Repetto formation. In addition, the Pico formation is divided into upper, middle, and lower divisions.

Pico Formation. The Pico formation is shown, where it outcrops at the surface, on Plate 3 by the symbol "P_p". The upper division or upper member of the Pico formation is a potential source of ground water. It has not been exploited to date, though wells along Carson Street near Lakewood do obtain water from upper Pico aquifers. This member is thickest in the synclinal areas, and it outcrops on the hills surrounding the coastal plain.

The upper Pico formation is generally composed of sand, silt, and clay of marine origin interbedded with marine gravels. Beds of gravels and sands range in thickness from 20 to 100 feet and are separated by beds of micaceous siltstone and clays.

Unconformably beneath this upper member are the middle and lower members of the Pico formation, or in some areas, the Repetto formation. The middle and lower divisions of the Pico formation are differentiated from upper Pico sediments by the contained foraminiferal faunas. Lithologically, the middle and lower divisions are composed of greenish-grey micaceous siltstone and fine to coarse light grey feldspathic sandstone interbedded with claystone and shale. The thickness of these lower division materials ranges from 400 to more than 2,000 feet. Throughout most of the coastal plain these rocks are far below the depths reached by the deepest water wells. Oil well data indicate that, although portions of these sediments may be sufficiently permeable to transmit water in usable quantities, the water is of poor quality and unsuitable for general use.

Repetto Formation. The Repetto formation, of early Pliocene age, is exposed in several areas adjacent to the coastal plain. The outcrops of this formation are identified by the symbol "Pr" on Plate 3. These deposits are composed mostly of siltstone with layers of sandstone and conglomerate, containing fragmental marine shells locally. The Repetto formation is about 5,000 feet in thickness. Wissler (1943) states that the maximum thickness occurs in the Montebello-Santa Fe Springs area. Conrey (1958) and Slosson (1958) confirm this and discuss the distribution and thickness of the Repetto rocks in some detail.

Miocene Series

Rocks of Miocene age are shown on Plate 3 by the symbols "Ms" for sedimentary rocks and "Mv" for volcanic rocks. Nomenclature of the sediments of Miocene age is somewhat complicated; however, the relationship between the various names and brief descriptions of the various formations are presented in Table 1.

Sedimentary Rocks. Sedimentary rocks of middle and late Miocene age have been called the Monterey formation in the Palos Verdes Hills, the Modelo formation in the Santa Monica Mountains, and the Puente formation beneath the coastal plain and in the Repetto and Puente Hills. These formations, up to 11,000 feet thick, consist predominantly of clay shales but siliceous shales, sandstones, and conglomerates are common.

The Topanga formation is of middle and possibly early Miocene age. It is interbedded with and lies below the Miocene volcanic rocks. The formation attains a thickness of 7,500 feet and consists of shale, sandstone, and conglomerate.

No wells are known to produce fresh water from these formations in the immediate area of the coastal plain. However, water wells in other parts of Southern California do obtain limited supplies from hard fractured shales and poorly consolidated sandstones and conglomerates of these formations.

Volcanic Rocks. Calcic andesite flows, tuffs, and breccias underlie at least parts of the coastal plain, and usually contain interbedded marine sand, conglomerate, and shale. Where these materials outcrop on the surface they are identified by the symbol "Mv" on Plate 3. Available data indicate that the fractured sills, dikes, and flows, along with interbedded sand and gravels, yield water to wells, while the conglomerates and agglomerates are relatively nonwater-bearing.

Older Tertiary Sedimentary Rocks

Rocks of Eocene and Oligocene age are missing beneath West Coast Basin, though they may underlie the Central Basin. Hoots (1931) gives some evidence for the presence of the Sespe and Vaqueros formations of Oligocene(?) or early Miocene age in the Santa Monica Mountains. Paleocene rocks crop out in the Santa Monica Mountains and may underlie a part of the coastal plain. Hoots (1931) termed these rocks the Martinez formation. Other exposures of Martinez sandstone and conglomerate were found in the Santa Monica Mountains by Durrell (1954) and others. Outcrops of Eocene and Oligocene rocks are shown on Plate 3 by the symbols "E" and "Ø", respectively, while outcrops of Paleocene rocks are marked by the symbol "E-K".

Cretaceous System

A sequence of Upper Cretaceous sediments within the Santa Monica Mountains are differentiated and have been called the Chico formation by Hoots (1931). Durrell (1954) however, appears to have divided the same sequence into the Chico and Trabuco formations. The symbol "K_s" represents the areas of outcrops of these rocks on Plate 3.

Quartz dioritic intrusive rocks, shown by the symbol "K_g" on Plate 3 have previously been assumed to be Jurassic by comparison with similar rocks in the Sierra Nevada (Durrell, 1954). On the basis of dating by lead-alpha activity ratios of intrusive rocks in Southern California, Larsen, et al (1958) suggests that these rocks are of an early Late Cretaceous age rather than Jurassic.

Jurassic System

Rocks, called the Catalina schist, crop out on the Palos Verdes Hills and are identified on Plate 3 by the symbol "J". These have been also referred to as the Western bedrock complex because they underlie Miocene rocks of the West Coast Basin. The age of these schistose rocks is questionable and, according to Woodford, et al (1954), may be either Mesozoic (when compared to the Jurassic Franciscan formation of the coast ranges) or Precambrian (when compared with the Pelona schist of the San Gabriel Mountains). In this report they are mapped as Jurassic.

Triassic System

Metamorphosed black shale and sandstone crops out in the Santa Monica Mountains and have been called the Santa Monica slate (Hoots, 1931) and the Santa Monica formation (Durrell, 1954). Intrusion of these rocks by the quartz dioritic magma was responsible for changing these rocks into grey to black slates, mica schists, and spotted slates. These rocks are dated as Triassic by comparison with similar rocks of Triassic age in the Santa Ana Mountains. In the coastal plain, these are presumably the oldest rocks known, although the Cataline schist mentioned under the Jurassic System may possibly be older. These Triassic rocks are identified on Plate 3 by the symbol "T_R".

CHAPTER V. GEOLOGIC STRUCTURE

Geologic structural features within the Coastal Plain of Los Angeles County have a pronounced effect upon ground water movement and storage. Faulting offsets aquifers, creates zones of cementation and low permeability, and generally disrupts the flow of subsurface waters. Folding and faulting raise aquifers either to or near the land surface, thereby enhancing the possibility of recharge. In some instances, uplifted fault blocks and folds are deterrents to ground water movement where structural highs of bedrock disrupt or change the course of ground water movement. Locally, aquifers are partially or entirely eroded away across these features, or are being dewatered because of the lowering of ground water levels. Elsewhere, ground water reservoirs are formed in structural lows created by faulting and synclinal folding of aquifers.

The tectonic forces which produced the structural deformation within and adjacent to the coastal plain were continuous throughout Tertiary time and possibly Quaternary time. This deformation, however, was most severe during mid-Miocene, Pliocene, and Pleistocene time. Sediments of Recent age have not been seriously disturbed, even though earth movements have been recorded during historic time.

Descriptions of individual geologic structures presented in this chapter are of necessity brief. Emphasis is given to those structures which influence ground water movement. Heretofore unrecognized or unpublished subsurface structural features have been noted during the course of this investigation. Most of these features are not evident from surface topography even though some of them affect relatively shallow sediments.

The structural characteristics of Pleistocene and Recent aquifers were determined by constructing geologic cross sections and maps showing lines of equal elevation on the bases of aquifers. Available geologic maps and subsurface maps of oil field structures were used to help determine the structural patterns of the various aquifers and underlying Tertiary formations. The locations of faults and fold axes in these Tertiary formations, however, do not necessarily coincide with locations of similar structures in the Pleistocene sediments.

Those structures which have a surface expression or which affect water-bearing sediments are included in the areal geology shown on Plate 3.

Regional Features

Geologic structures within and bordering the coastal plain are generally aligned along regional uplifts and depressions. For descriptive purposes, these are herein grouped into the "Mountain and Foothill structures", "Transitional structures", the "South Gate-Santa Ana depression", the "Newport-Inglewood uplift", the "Hawthorne-Long Beach depression", and "Offshore structures". These structural systems are reasonably distinct, but where systems join, local structural features may be common to each of the systems.

The coastal plain is bordered to the north, northeast, and southwest by mountains and hills which have been uplifted by folding and faulting. The hills bordering the northeast margins of the coastal plain are flanked to the south by the Transitional structures consisting of partially buried anticlines and synclines. The Transitional structures do not constitute one structural system but are grouped together because of their relative positions. The South Gate-Santa Ana depression, a general northwest trending synclinal depression, underlies the Downey Plain and extends from the La Brea Plain to beyond the investigational area into Orange County. The South Gate-Santa Ana depression is bordered on the northeast by transitional structures and on the southwest by the Newport-Inglewood uplift, a system of echelon faults and anticlinal folds. In Los Angeles County, the Newport-Inglewood uplift is bordered on the southwest by the Hawthorne-Long Beach depression, a synclinal depression, which underlies the Torrance Plain and extends northwest from the City of Long Beach toward the Santa Monica Mountains. On the west side of the Hawthorne-Long Beach depression, beneath the El Segundo Sand Hills, water-bearing sediments of Pleistocene age rise gently as a homocline toward Santa Monica Bay. The Offshore structures affect the water-bearing sediments extending beneath the Santa Monica and San Pedro Bays.

Mountain and Foothill Structures

The northern and eastern margins of the coastal plain are bordered by the Santa Monica Mountains and the Elysian,Repetto, Merced, and Puente Hills. The Palos Verdes Hills border the plain to the southwest. These highlands are almost entirely composed of rocks of pre-Tertiary and Tertiary age and are essentially nonwater-bearing. Therefore, only brief mention of the structural nature of each of these areas will be made. Detailed description of geologic structures within these highlands may be found in many of the references listed in the Bibliography. Between the Merced and Puente Hills is the Whittier Narrows, an erosional gap. Since it is closely associated with the highlands and is the location of the major subsurface flow to the ground water basins of the Coastal Plain of Los Angeles County, the structures within it are described in detail in this section.

Santa Monica Mountains

The Santa Monica Mountains (Plate 2) are essentially a westerly plunging, asymetric anticline that has had a complex history of development. The anticline has been faulted, deformed by secondary folding, and further complicated by igneous intrusion. Important periods of deformation are recorded by several major unconformities between various formations of Cretaceous and Tertiary age. The Hollywood fault extends along the southern edge of the Santa Monica Mountains and at depth serves as the northerly edge of the Hollywood Basin, one of the ground water basins included in the coastal plain. The fault is buried by sediments of Pleistocene and Recent age.

Elysian Hills

Principal structures in the Elysian Hills include the Elysian Park anticline and secondary folding and faulting which deform its southern flank. The Elysian Park anticline extends southeast across the Los Angeles Narrows and through the Repetto Hills. In the Los Angeles Narrows, the structure has been cut by erosion and Miocene and Pliocene sediments are unconformably overlain by sediments of late Pleistocene and Recent age.

Repetto and Merced Hills

The Repetto and Merced Hills are essentially continuous but are structurally separated by a westerly trending syncline. In both uplift areas, angular unconformities locally exist between Tertiary sediments and the San Pedro formation, and between the San Pedro and Lakewood formations.

North of the San Bernardino Freeway, the Repetto Hills are formed into three nearly parallel fold systems which trend slightly north of west. These consist of a syncline which separates the Highland Park-South Pasadena anticlinal system on the north from the Elysian Park anticline on the south. The Elysian Park anticline is flanked on the south by another syncline and then the Boston Heights anticline.

South of the San Bernardino Freeway, the Repetto Hills are a westerly trending, southerly dipping homocline that is cut by the Coyote Pass fault west of Atlantic Boulevard. The Coyote Pass fault extends westerly along the south flank of the hills, and brings sediments of Pliocene age into fault contact with those of Pleistocene age.

The Merced Hills are a westerly trending, structural high developed by faulting and anticlinal folding. Major structures include the North Montebello thrust fault and the Montebello anticline. These structures are exposed at the surface and are developed in sediments of Pliocene and Pleistocene age. The anticlinal structures containing the East and West Montebello oil fields are developed at depth in sediments of Tertiary age, and are not reflected in water-bearing sediments of Pleistocene and Recent age.

Whittier Narrows Area

The Whittier Narrows area is not itself an uplift, but is a structurally controlled erosional gap located between and structurally related to the adjacent Merced and Puente Hills. Beneath the Whittier Narrows, the sediments of the San Pedro formation, and possibly the Pico formation, are folded into a northeast trending, synclinal depression. Southwest of the Whittier Narrows Dam, the subsurface structure is further complicated by both block faulting and transverse folding. Sediments of the Lakewood formation unconformably overlie the syncline and are only slightly deformed (Section P-P', Plate 6G).

The synclinal structure underlying the Whittier Narrows separates the anticlinal form of the Merced Hills on the west from the essentially anticlinal structure of the Puente Hills on the east. These anticlinal structures have been cut through by erosion, and are locally interrupted by faulting. The Montebello anticline plunges east into the Whittier Narrows and is reflected in sediments of the San Pedro formation. The anticlinal structure of the Puente Hills, in its western extremity, is cut by the Cemetery fault, as hereafter presented.

The structure of that portion of Whittier Narrows lying directly southwest of the Whittier Narrows Dam is exceedingly complex, and the available data may be interpreted to derive two differing patterns of subsurface structure. One explanation of a portion of the data would picture sharp folding of the sediment parallel to the northeast-southwest trending synclinal axis, possibly coupled with the extension of the Whittier fault through Whittier Narrows perpendicular to the synclinal axis. After careful analysis, however, this theory was held to be inadequate in explaining all data.

This report therefore presents the subsurface structure of Whittier Narrows as being governed by three faults generally parallel to the axis of the syncline. The following discussion of the structural system in the Whittier Narrows is based on the presence of these assumed faults. These faults have been named, from east to west, the Cemetery, Pico, and Rio Hondo faults, and they divide the area into two fault blocks that are tilted to the west. (Plates 3, 6A, and 6G). The available evidence also indicates that within the Whittier Narrows, water-bearing sediments of Pleistocene and Recent ages are not offset by the Whittier fault. Vertical offsetting along the three parallel faults occurs primarily in the uppermost Pico and San Pedro formations; local displacement of the Lakewood formation occurs along the southern extent of the Rio Hondo fault (Section A-A'-A", Plate 6A). Sediments of Recent age are not disturbed by these faults. Considerable merging of aquifers occurs throughout the narrows and is related to displacement along faults and to unconformities among aquifers of Pleistocene and Recent ages. The pattern of the aquifers and their relationship to the fault system in this area are shown pictorially in the cut-away diagram on Plate 7.

The Rio Hondo fault is about four miles long and generally follows the east side of the Rio Hondo. West of the fault, aquifers of the San Pedro formation are raised close to the surface and are unconformably overlain by the Gardena and Gaspur aquifers (Section A-A'-A", Plate 6A).

The Pico fault, which can be traced for about three miles, is located about one mile east of, and essentially parallel to, the Rio Hondo fault. The fault block west of the Pico fault has been raised relative to that of the east side. The vertical displacement of the San Pedro formation brings different aquifers into hydraulic continuity with each other across the structure, as illustrated on Section A-A'-A", Plate 6A.

The Cemetery fault extends for about two miles along the east margin of the Whittier Narrows, and apparently displaces the west extent of the Puente Hills. The fault block west of the fault is downthrown relative to the east side. Available evidence suggests that the Cemetery fault terminates at the Whittier fault, and is possibly related to this major shear zone.

Two complexly folded and tilted fault blocks are developed between the Rio Hondo, Pico and Cemetery faults. The western block is downthrown on the Rio Hondo fault, and upthrown on the Pico fault. Within this fault block, sediments of the upper Pico and San Pedro formations are folded into an anticline, which trends northeast and crests adjacent to the Pico fault. This high disrupts the synclinal depression in its southwest extremity, as shown by contours drawn on the base of the Sunnyside aquifer (Plate 22). The Gardena aquifer unconformably overlies the anticline and the truncated aquifers of the San Pedro formation. (Section P-P', Plate 6G).

The eastern fault block is downthrown between the Pico and Cemetery faults. Within this block, the San Pedro formation is gently folded as shown on Section N-N'-N", Plate 6F, and by contours drawn on the base of the Sunnyside, Silverado and Lynwood aquifers (Plates 22, 20, and 18). Sediments of the Lakewood formation unconformably overlie these gentle folds, and the Gardena Aquifer merges with the Jefferson aquifer locally across these flexures.

Puente Hills and Whittier Fault Zone

The Puente Hills are essentially a west trending anticline that is complicated by secondary folding and faulting. The predominant structural feature of the Puente Hills is the Whittier fault or fault zone. This major structure trends southeast along the south flanks of the Puente Hills and extends from the vicinity of the Whittier Narrows into Orange County. Northeast of the City of Whittier, the principal fault separates into a complex of smaller breaks and probably diminishes as it approaches the Whittier Narrows. Available oil well data indicate that it is a high angle reverse fault, with the north side rising over the south side at an angle of approximately 70 degrees. Offset drainage of La Mirada Creek and Turnbull and Brea Canyons in Orange County suggest that right lateral displacement has occurred along the fault in relatively late geologic time, the southwest side having moved several thousand feet northwest relative to the northeast side.

The Puente Hills have been uplifted by vertical displacement along the Whittier fault and by normal faulting along the Workman Hill, Handorf and Rowland fault systems. The hills are further characterized structurally by minor faults, unconformities, and tight and overturned folds in sediments of Miocene, Pliocene and Pleistocene age. South of the Whittier fault zone, an angular unconformity exists between Pico and overlying San Pedro sediments, but both formations have a general southerly homoclinal dip into the La Habra syncline.

Palos Verdes Hills

The Palos Verdes Hills are an uplifted fault block composed of Catalina schist basement and marine sediments of Tertiary and Quaternary age that have been folded into a general anticlinal form. This general anticlinal high extends through the central portion of the hills and may extend beneath alluvial cover into the San Pedro area; it may also continue as a subsea structure beneath the San Pedro Shelf (Moore, 1951).

A fault which extends in a northwest direction along the northern boundary of the hills has been termed the "Palos Verdes Fault Zone" by Woodford, et al (1954). This break, although only partially reflected at the surface by minor faults and steep northeast dipping sediments of Miocene, Pliocene and Pleistocene age, offsets Catalina schist basement at depth. Test drilling by the Los Angeles County Flood Control District has verified the continuity of this fault zone out into the Pacific Ocean near Redondo Beach.

The Gaffey anticline and the Gaffey syncline extend northwest along the northeastern portion of the Palos Verdes Hills. These folds plunge southeast and apparently extend beneath Recent alluvium east of the hills and into San Pedro Harbor where they may affect ground water movement.

Transitional Structures

Transitional structures are those structural features that lie along the generally south-dipping homoclinal flanks of those mountain and foothill structures to the north and east of the coastal plain. They are also north and northeast of the South Gate-Santa Ana depression. A few of these structures have topographic expression; the remainder are buried beneath upper Pleistocene and Recent sediments. These structures, like most on the coastal plain, are generally best developed in Miocene and Pliocene formations, and for the most part have been determined from subsurface oil exploration studies.

From northwest to southeast, the Transitional structures include the Hollywood syncline, La Brea high, Boyle Heights anticline, Bandini anticline, East Los Angeles anticline, the Santa Fe springs-Coyote Hills uplift, and La Habra syncline. Since the Bandini and East Los Angeles anticlines are developed at depth and do not appear to affect the overlying water-bearing sediments, they are not included in the following discussions of the other Transitional structures.

Hollywood Syncline

The Hollywood syncline is a downwarped area between the Santa Monica Mountains to the north and the La Brea Plain to the south. The syncline plunges to the southwest where it may be displaced by the Inglewood fault. Northeast of Western Avenue the flexure becomes ill defined and is apparently broken up by upfaulted blocks of Tertiary bedrock. The location of the synclinal axis, as shown by the areal geology on Plate 3A is inferred from available subsurface data.

Ground water moves south and west from the syncline. The Santa Monica Mountains and the Hollywood fault, which truncate the syncline's northern flank, are complete barriers to ground water movement to the north and east. To the south and southeast, ground water movement is impeded by the La Brea high.

La Brea High

The La Brea Plain is closely underlain by a structural high developed in sediments of Tertiary age and unconformably overlain by 100 to 200 feet of the Lakewood formation. The structural nature of the high is known in part. The northwestern portion of the high, which contains the Salt Lake oil field, includes a northwest plunging anticline, a northwest plunging syncline, and a southwest plunging anticline, all in Miocene rocks. South of these folds the structural configuration of bedrock is largely unknown. The south dipping monocline of Tertiary sediments in the Los Angeles oil field may extend west beneath the southern portion of the La Brea Plain and could be the upper expression of the east-west trending Santa Monica fault system described by Barbat (1958).

The crest of the La Brea high is located about one mile south of, and generally parallel to, Santa Monica Boulevard from Western Avenue to near the Inglewood fault. This feature plunges steeply in its western extremity, and the San Pedro formation is continuous from the south into the Hollywood syncline around the warped slope thus formed. Across the crest of the high, sediments of the San Pedro formation have been removed by erosion. Ground water movement from the Hollywood syncline south across the La Brea high is therefore limited to aquifers of the Lakewood formation, and to the San Pedro formation around the western nose of the La Brea high.

Boyle Heights Anticline

The Boyle Heights anticline contains the Boyle Heights oil field. This structure, developed in sediments of Miocene, Pliocene and Pleistocene age, is essentially a minor anticlinal flexure on the south dipping homoclinal flank of the western Repetto Hills. The anticlinal axis trends southeast; the crest approximately underlies the intersection of 4th and Soto Streets. The fold is asymetric with the north flank dipping more gently than the south flank. Well logs show that the San Pedro formation has been eroded from the crest of the anticline. The Lakewood formation, here approximately 250 feet thick, unconformably overlies the Repetto formation at the crest and the San Pedro formation along the southern flanks of the anticline. Ground water movement across the structure is restricted due to anticlinal folding, thinning of water-bearing section over the crest and the nonwater-bearing core of the Repetto formation.

Santa Fe Springs-Coyote Hills Uplift

The surface of the Santa Fe Springs Plain and the Coyote Hills reflects a structural high which trends northwest from the Coyote Hills in Orange County and is primarily developed in underlying formations of Miocene and Pliocene age. In these sediments, the uplift consists of anticlinal folds which contain the Santa Fe Springs, Leffingwell, and West Coyote oil fields. The San Pedro and Lakewood formations are similarly folded across the uplift, and the folds developed in these sediments generally correspond to the underlying structures.

Santa Fe Springs Anticline. The Santa Fe Springs oil field is contained in an elongated anticlinal dome which trends northwest and underlies the Santa Fe Springs Plain. The fold is symmetrical and has gently dipping flanks. The San Pedro and Lakewood formations are folded over the structure and have a minimum combined thickness of 700 feet above the dome. Contours depicting the base of Pleistocene aquifers show that in the San Pedro and Lakewood formations the fold crest is located slightly north of the axis as defined by the Pliocene beds of the oil reservoir. Contours depicting the base of fresh-water materials correspond to the structural high and indicate that in this area the uppermost Pico sediments contain fresh water.

While some of the shallow aquifers thin out in the area of the Santa Fe Springs anticline, it does not otherwise affect movement of ground water.

Leffingwell Anticline. The Leffingwell oil field is located approximately two miles east of the Santa Fe Springs oil field and is contained in a faulted, eastward plunging, anticlinal nose developed in sediments of Tertiary age. The anticline is offset in its central portion by two northern trending faults which are not definable above sediments of Miocene age. Contours of the base of the Silverado aquifer (Plate 20) reflect the underlying high, but no effect on the movement of ground water is known.

West Coyote Anticline. The West Coyote anticline, an elongated dome, contains the West Coyote oil field and is defined in the outcropping San Pedro formation within that portion of the Coyote Hills immediately east of the Los Angeles-Orange County line. The anticline trends east-west and is complicated by faulting in the central and western portion and by secondary folding. Dips on the south flank are steeper than on the north flan. Contours of the base of lower Pleistocene aquifers show that the anticline plunges west into Los Angeles County. The coarse gravels exposed at the surface and across the crest are believed to be the Sunnyside aquifer. The uplifted, relatively impermeable upper Pico formation acts as a barrier to the movement of ground water across the anticline.

La Habra Syncline

This syncline is located between the Puente Hills on the north and Santa Fe Springs-Coyote Hills uplift on the south. The axis of the syncline trends slightly north of west and its location (Plate 3) is inferred from available subsurface data. Water-bearing materials extend up both limbs of the syncline and outcrop in the Puente Hills and the Coyote Hills. The syncline is closed at the eastern end by the northeast trending East Coyote anticline. Available data suggests that a saddle exists at the western end of the structure where it disappears into the Whittier Narrows area.

South Gate-Santa Ana Depression

The South Gate-Santa Ana depression is the generally downwarped area which underlies the Downey Plain. The depression trends northwest between the Baldwin Hills and the La Brea Plain and extends beyond the investigational area into Orange County. The Newport-Inglewood uplift borders the depression on the southwest in Los Angeles County. The La Brea Plain, Elysian Hills, Montebello Plain, Santa Fe Springs, Coyote Hills, and Santa Ana Mountains border the depression to the northeast. Minor anticlinal folds or warps lie along the limbs of this synclinal depression.

As shown on the geologic cross sections, sediments of lower Pleistocene age have been folded to a greater extent than upper Pleistocene and Recent materials. The trough in older sediments lies in the central portion of the plain, about one mile southwest of Huntington Park. In upper Pleistocene sediments it lies west of the central portion of the Downey Plain in the vicinity of Carson Street and Palo Verde Avenue. Recent alluvium is generally flat lying, although slight local folding occurs in the Whittier Narrows. The major structural features in the South Gate-Santa Ana depression are the Paramount Syncline and Los Alamitos fault, and the Norwalk Syncline.

Paramount Syncline and Los Alamitos Fault

The principal axis of the depression, determined from aquifers of the San Pedro formation, is named the Paramount syncline. This structure underlies the City of Paramount and extends northwesterly to the Inglewood fault. South of Huntington Park the trend of the synclinal axis changes from northwest to slightly north of west, as shown on Plate 3.

Southeast of the City of Paramount an extension of the axis of the Paramount syncline coincides with the Los Alamitos fault. This fault trends southeasterly from one mile north of the City of Lakewood and extends about six and one-half miles to the southwest limits of the Los Alamitos Naval Reservation. Apparent movement along the fault appears to have been vertical with the aquifers to the east of the fault having moved down relative to those of the west. Aquifers of late Pleistocene and Recent age apparently have not been displaced. Merging of differing aquifers occurs across the fault because of their vertical displacement. Water quality and water well logs on either side of the structure indicate that movement of ground water across the fault is only slightly affected.

The manner in which the Los Alamitos fault continues on as an apparent extension of the Paramount syncline suggests that the displacement of aquifers in this area might be a result of folding of the sediments rather than the postulated faulting. However, the available data are primarily derived from water well drillers logs and water quality data, indicate the presence of a fault, possibly the same fault believed by some petroleum geologists to exist in this area in the older sediment underlying the San Pedro formation. Subsequent drilling may resolve the question as to whether this feature is actually a fold or a fault.

Norwalk Syncline

The Norwalk syncline is located south of the Coyote Hills and extends southeast from the City of Norwalk into Orange County. As shown by contours depicting the base of the Silverado aquifer (Plate 20A), the syncline plunges northwesterly toward the City of Norwalk.

Newport-Inglewood Uplift

The Newport-Inglewood uplift is an important regional structure extending from Newport Mesa in Orange County northwesterly approximately 40 miles to its terminus in Beverly Hills. At depth, the uplift is considered a complex fault system that serves as the boundary between Catalina schist basement to the west and granitic basement to the east. At the surface it is characterized by a series of echelon faults and anticlinal folds and domes which underlie the Beverly, Baldwin, Rosecrans, Dominguez, Signal, Bixby Ranch and Landing Hills (Plate 2). Formations on both flanks of the uplift dip away from the axis. The anticlines are characteristically closed at both ends and are separated by structural saddles. The structures forming the uplift are deformed by high-angle normal and reverse faults at the surface and, at depth, Tertiary sediments are offset by low angle reverse faults.

The faults of the Newport-Inglewood uplift in some cases exert considerable barrier influence upon the movement of subsurface water. In other places sediments offset by the faults have been scoured and backfilled by ancient rivers and streams so that in these areas the faults offer little or no restraint to the movement of ground water. Offsetting of sediments along these faults is usually greater in the deeper, older formations. Displacement is less in younger, stratigraphically higher formations. In the Pleistocene deposits and on the surface, actual displacement by faulting is minor and folding is predominant.

The folds and faults of the Newport-Inglewood uplift, from north to south, include the Beverly Hills dome, Inglewood fault, the Baldwin Hills uplift, Potrero fault and dome, the Rosecrans anticline, Avalon-Compton fault, Dominguez and Long Beach anticlines, Cherry Hill, Northeast Flank, Pickler, and Reservoir Hill faults, and the Seal Beach structure. The structural features of the Newport-Inglewood uplift are described in the following sections.

Beverly Hills Dome

The Beverly Hills dome, a small fold developed at depth in sediments of Tertiary age, is the northernmost anticlinal structure of the Newport-Inglewood uplift. The dome, which contains the Beverly Hills oil field, is apparently not reflected in overlying sediments of Pleistocene and Recent age. Pleistocene formations in the area have reportedly been penetrated by only a few water wells on which data are not available. Available oil well information, however, indicates that Pleistocene sediments dip northwesterly away from the Baldwin Hills and toward the Santa Monica Mountains.

Inglewood Fault

The Inglewood fault is approximately nine miles long, trends northwest-southeast, and extends from approximately one mile south of the City of Beverly Hills to nearly two miles southeast of the City of Inglewood. An eroded escarpment which is probably the surface expression of the Inglewood fault is present in the Cheviot Hills (Poland, et al 1949).

Beneath Ballona Gap, the fault offsets aquifers of Pleistocene age as shown on section A-A'-A", Plate 6A. In this area, the sediments east of the fault have dropped down relative to those on the west side and the fault forms a barrier to ground water movement. Between the Cheviot Hills and the Santa Monica Mountain front, the presence of the Inglewood fault and its probable effect on ground water is largely conjectural. Water level data for the vicinity of Beverly Hills, however, suggest that the fault does not affect water-bearing sediments in that area.

In the Baldwin Hills, the Inglewood fault is marked at the surface by an escarpment along which over 200 feet of vertical displacement has been measured (Driver, 1943). Available evidence indicates that displacement along the fault is both normal and right lateral, the latter being the principal movement. The fault dips steeply west and is offset by several cross faults which trend northeast. In the Baldwin Hills, the west block is dropped; between the Baldwin Hills and Ballona Gap, therefore, pivotal movement must have occurred as the west block is uplifted in Ballona Gap.

South of the Baldwin Hills, the Inglewood fault has also been called the Townsite fault (Willis and Ballantyne, 1943) and is offset by the Fairview Avenue and Centinela Creek faults which trend northeast. The

Inglewood fault offsets aquifers of the San Pedro formation as shown on section B-B'-B", Plate 6A, and forms a partial barrier to ground water movement in the vicinity of the City of Inglewood.

Baldwin Hills Uplift

The Baldwin Hills, containing the Inglewood oil field, are underlain by a faulted, northwest-trending anticline which is developed in sediments of Tertiary and Pleistocene age. Two principal northwesterly trending, nearly parallel faults offset the central portion of the hills, developing a downdropped block or graben across the crest of the anticline. The more easterly of the two structures is the Inglewood fault, described in preceding paragraphs; the other fault is unnamed. Both faults are offset by secondary cross faults which trend northeast. The block east of the Inglewood fault is composed of sediments of Pliocene age and older and is cut by several small unnamed faults. One such fault extends along the northeast border of the Baldwin Hills and may be related to the prominent excarpment in that area. The Slauson Avenue fault extends northeast beyond the Baldwin Hills and offsets aquifers of the San Pedro formation.

The Baldwin Hills form a complete barrier to ground water movement where the essentially nonwater-bearing Pico formation crops out (Plate 3A).

Potrero Structures

This term is assigned to those structures of the Newport-Inglewood uplift which are located between the Baldwin Hills to the northwest and the Rosecrans anticline to the southeast. Principal structures include the Inglewood and Potrero faults and the Potrero dome. The faults are continuous from the Baldwin Hills to the Rosecrans anticline, but the dome is an independent structural feature.

The Inglewood and Potrero faults extend southeast from the Baldwin Hills and border a linear, tilted block, approximately four miles long and several thousand feet wide, which is broken into smaller blocks by several nearly parallel, northeasterly trending cross faults (Plate 3A).

Potrero Fault. The Potrero fault is about four miles long and is expressed at the surface as an escarpment along the west flank of the Rosecrans Hills. It is essentially a fracture zone, 100 to 200 feet wide, that trends northwesterly and dips steeply to the west. Both normal and right lateral displacements have been observed, but the latter is more pronounced. In those areas where vertical displacement of aquifers exists, the fault acts as a barrier to subsurface flow, as was shown by a pumping test conducted in the Inglewood oil field.

A series of transverse faults cut both the Inglewood and Potrero faults and enclose a number of tilted, uplifted or downdropped blocks. From north to south these faults are: The Slauson Avenue fault, Fairview Avenue fault, Centinela Creek fault, Inglewood Park Cemetery fault, Manchester Avenue fault, and the Century Boulevard fault. These faults probably offset aquifers of Pleistocene age and are believed to act as partial barriers to ground water movement (Poland, et al 1959).

Potrero Dome. The Potrero dome, primarily developed at depth in sediments of Tertiary age, is located immediately east of the City of Inglewood and contains the Potrero oil field. The dome trends northwest and is offset by the Inglewood and Potrero faults. Dips along the flanks are gentle, becoming steepest to the north and east.

Rosecrans Anticline

Defined by aquifers of the San Pedro formation, the Rosecrans anticline trends northwest and extends for approximately five miles near the middle of the Newport-Inglewood uplift in Los Angeles County and lies beneath the Rosecrans Hills. The Howard Townsite, Rosecrans, and South Rosecrans oil fields underlie this Pleistocene structure, and are developed in sediments of Tertiary age. These oil structures are offset and complicated by several nearly parallel, westerly trending thrust faults which do not affect sediments of Pleistocene age. Thinning and pinching out of the aquifers across the anticline may be a deterrent to ground water movement between the Central Basin and the West Coast Basin.

Avalon-Compton Fault

The Avalon-Compton fault is about two and one-half miles long and trends northwesterly from the north flank of Dominguez Hill to the south end of Rosecrans anticline. The normal displacement along the fault increases with depth, and the southwest block is dropped. The fault offsets the Silverado, Lynwood, and Gardena aquifers, as shown on Section D-D'-D", Plate 6B. Water level differences on either side of the fault indicate that this structure is an effective ground water barrier (Poland, et al 1959a).

Dominguez Anticline

The structure underlying Dominguez Hill and containing the Dominguez oil field has been described by Grinsfelder (1943) as an elliptical, northwesterly trending anticline. Similar to most structures on the Newport-Inglewood uplift, the anticline, fully developed in the deeper

Tertiary formations, is also reflected in Pleistocene sediments at the surface. Dominguez Hill, rising about 150 feet above the surrounding land surface, is typical of this relationship. The anticline is offset by high angle normal faults and lower angle reverse faults at depth. This deformation does not appear to extend more than 4,000 feet below sea level. The base of Pleistocene sediments across the anticlinal crest is about 400 feet below sea level and it is believed that the aquifers are not affected by faulting across the anticline. The southwest flank of the anticline dips more steeply than the northeast flank. The extreme northwest flank of the structure is cut by the Avalon-Compton fault, described above.

Long Beach Anticline

The Long Beach anticline is a narrow, elongated, asymmetrical structure which trends northwest and is offset by several prominent faults. The structure extends approximately five miles through Signal Hill and Reservoir Hill and contains the Long Beach oil field. The plunge of the axis is less to the northwest than to the southeast. Dips on the southwest flanks are generally steeper away from the crest than dips on the northeast flanks. Three prominent faults, the Cherry Hill, Northeast Flank, and the Reservoir Hill faults, trend northwest along the crest of the anticline. A short, transverse fault, the Pickler fault. extends across the crest of the anticline from the northern expression of the Northeast Flank fault to the Cherry Hill fault. A surface scarp along the north side of the Bixby Ranch Hill may be a surface expression of a fault, but subsurface evidence available at this time does not clearly confirm this.

Available data in the Signal Hill and Reservoir Hill areas and in that portion of the City of Long Beach adjacent to and west of the Resevoir Hill fault are insufficient for definition of aquifers in these areas and for correlation of aquifers across the Pickler, Northeast Flank, and Reservoir Hill faults. According to Poland, the Signal Hill area is a complete barrier to movement of ground water between the Long Beach Plain and the Downey Plain. No new evidence was available to confirm or disprove this assertion. Even though data are sparse, however, it is apparent that the structural character of Signal Hill and Reservoir Hill is sufficient to restrict ground water movement.

Cherry Hill Fault. Stolz (1943a) designated the fault that extends along the southwest flank of the Long Beach anticline as the Cherry Hill fault. Movement along the fault is up on the northeast side and down on the southwest side. Vertical displacement of water-bearing sediments is considerable for several miles along this fault. Along the southwest side, the Silverado aquifer, for example, has been displaced against older rocks of low permeability. Northeast of the structure at Signal Hill, these rocks of low permeability rise above the zone of saturation.

The Cherry Hill fault extends across Dominguez Gap and disappears along the northeast flank of Dominguez Hill. Although the fault does not act as a barrier to movement of ground water in the Gaspur aquifer, it does have a barrier effect in the underlying formations in Dominguez Gap (Poland, et al 1946b).

Northeast Flank Fault. The Northeast Flank fault, also named by Stolz (1943), extends along the northeast flank of Signal Hill for about one mile. The northeast side of the fault is downdropped relative to Signal Hill, which is an uptilted block between this fault and the Cherry Hill fault. In this area, Pleistocene aquifers have apparently been entirely offset and ground water movement is impeded by the Northeast Flank fault.

Pickler Fault. The Pickler fault is a transverse fault which strikes southwest along the northwest margin of Signal Hill. Its existence was inferred largely from a difference in the productivity of oil wells on either side of the fault. The area northwest of the fault is downdropped relative to Signal Hill. The vertical displacement at the base of the San Pedro formation is believed to be about 150 feet. This displacement brings sediments of relatively low permeability in the block to the southeast into contact with the water-bearing sediments to the northwest.

Reservoir Hill Fault. The Reservoir Hill fault is a normal, steep, northeasterly dipping fault aligned with the northeast flank of Reservoir Hill. The fault trends southeast and is named the Seal Beach fault in Alamitos Gap and Landing Hill. It is in echelon with the Northeast Flank fault. The southwest side of the fault has moved up in relation to the northeast side. Vertical displacement along the fault, about opposite the crest of Reservoir Hill, is about 280 feet. Materials of the San Pedro and underlying Pico formation have been displaced by at least this amount; however, no displacement occurs within the uppermost alluvial deposits of Recent age. The fault is believed to restrict ground water movement in Alamitos Gap (Poland and Sinnott, 1959b).

Seal Beach Structure

The Seal Beach structure, containing the Seal Beach oil field, consists of two elongated domes separated by a saddle. The domes are developed in underlying sediments of Tertiary age, trend northwesterly, and are offset by the Seal Beach fault, the local name applied to the southern portion of the Reservoir Hill fault. The more northerly dome underlies Bixby Ranch Hill; the southerly dome has its apex in Alamitos Gap under the present channel of the San Gabriel River. Bowes (1943) stated that the San Gabriel River is antecedent to the later periods of folding and its position may have been controlled by the saddle that exists between these two domes.

Hawthorne-Long Beach Depression

The Hawthorne-Long Beach depression is the downfolded area that underlies the El Segundo Sand Hills, Torrance Plain, Dominguez Gap, Long Beach Plain, and most of the Santa Monica and Sawtelle Plains, but only portions of Beverly Hills and Ballona Gap. The depression trends northwesterly and extends from its northwestern terminus at the base of the Santa Monica Mountains to the City of Long Beach and continues offshore beneath San Pedro Bay. It is bounded on the west by the Pacific Ocean, on the southwest by the Palos Verdes Hills and on the northeast by the Newport-Inglewood uplift.

The following structures lie within the depression and are briefly discussed in the succeeding paragraphs: Overland Avenue and Charnock faults, the Gardena syncline, the Torrance and Wilmington anticlines, the Lomita syncline, and unnamed structures beneath the Santa Monica Plain.

Overland Avenue Fault

The Overland Avenue fault trends northwest and extends from Santa Monica Boulevard to the northwest flank of the Baldwin Hills. Displacement of the fault is believed to be vertical, with a magnitude of approximately thirty feet. The northeast side of the fault is raised relative to the southwest side. Over a 15-year period, water levels east of the fault have remained 60 to 100 feet higher than those west of the fault (Poland, et al 1959a), indicating its relative effectiveness as a barrier to the movement of ground water.

Charnock Fault

The Charnock fault extends southeast from near Venice Boulevard to the City of Gardena and runs parallel to the axis of the Gardena syncline for most of its length. The northeast side of the fault is downthrown relative to the southwest side. Because of the displacement of lower Pleistocene aquifers as shown on Section C-C'-C", Plate 6B, the fault acts as a partial barrier to ground water movement. This barrier effect increases as the fault approaches the Ballona Escarpment, and then apparently diminishes as it continues northwest beyond Ballona Gap into the Sawtelle Plain.

Gardena Syncline

The principal structure of the Hawthorne-Long Beach depression is the Gardena syncline, an elongated, northwesterly trending flexure extending from Culver City to the City of Long Beach. It parallels the Newport-Inglewood uplift which borders it on the northeast. Along the southwest border, beneath the El Segundo Sand Hills, Pleistocene sediments gently dip northeasterly into the syncline from beneath the Pacific Ocean. The syncline is best developed in Tertiary and lower Pleistocene sediments and is moderately defined in upper Pleistocene sediments. Its deepest part, as shown on the contour map of the Silverado aquifer (Plate 20B), lies beneath the intersection of Alameda Street and Carson Street. From the northwest, the synclinal axis plunges gently into this low. The axial plunge from the southeast is relatively steeper.

Northwest of the City of Gardena, lower Pleistocene aquifers along the southwest flank of the syncline are offset by the Charnock fault (Section C-C'-C", Plate 6B), though the Gardena aquifer of late Pleistocene age is not displaced. Further north, beginning at the south margin of the Ballona Gap, the northeast flank of the syncline is displaced by the Overland fault. Beneath Ballona Gap and continuing northwest to approximately the Santa Monica Plain, the syncline becomes a downfaulted block lying between the Charnock and Overland Avenue faults.

Torrance Anticline

The Torrance anticline, located in the southerly part of the Hawthorne-Long Beach depression, is a gentle fold which trends southeast from Redondo Beach and contains the Torrance oil field. In sediments of Tertiary age, several echelon faults trend diagonally across the principal fold, dividing it into three elements. The water-bearing formations are affected by the broad, gentle folding, but available evidence indicates that they are not offset by faulting.

Wilmington Anticline

The Wilmington anticline is essentially continuous with the Torrance anticline but the two are separated by a structural saddle developed in sediments of Tertiary age. The anticline plunges to the northwest and to the southeast and, according to Winterburn (1943), consists of five blocks developed by several faults. The San Pedro and Lakewood formations are not affected by these faults, and only the San Pedro formation is folded.

Lomita Syncline

The Lomita syncline is located between the Torrance-Wilmington anticlinal highs to the north, and the Palos Verdes fault zone and Gaffey anticline to the south. The syncline parallels the southeasterly trend of these bordering uplifts and extends southeast from the City of Redondo Beach. Similar to the Gardena syncline, it is best developed in San Pedro and older sediments.

Unnamed Structures

Hoots (1931) and Barbat (1958) indicate that there are structures under the alluvial cover of the Santa Monica Plain which trend east-west and parallel to the structural trend of the Santa Monica Mountains. Since there is little subsurface information available in this area, the geologic structure is inferred on Section G-G', Plate 6D. This section shows the San Pedro formation dipping gently to the south beneath Ballona Gap and the Torrance Plain.

Offshore Structures

Those structures that lie beneath Santa Monica and San Pedro Bays have a direct effect upon the water-bearing strata that extend into these areas. Much work remains to be done to determine the nature and extent of offshore folding and faulting and their effects on ground water. The general structure of the offshore region is discussed by Emery (1954) as follows:

> "In general, the region consists of many blocks of roughly equal size that bear a close resemblance to the fault blocks of the Basin Range province in Nevada and eastern California. . .The slopes that bound the blocks are fairly straight and steep (5° to 10° average and more than 40° locally), and some terminate downward in linear depressions similar to sag ponds. Earthquake epicenters are more frequent on the basin side of these slopes, suggesting that the slopes reflect the presence of normal faults that separate horsts and grabens, though later work may show that some of them are due to folding rather than to simple block faulting."

The Santa Monica shelf as a whole is a seaward continuation of the coastal plain, and available information suggests that the San Pedro formation becomes thinner there. The pattern of sea-water intrusion indicates that aquifers are exposed to the ocean all along the Santa Monica Bay.

The San Pedro shelf is underlain by the seaward extension of the anticline that comprises the Palos Verdes Hills, by the Gaffey syncline and anticline, by the Lomita syncline, and the Wilmington anticline. Available subsea data suggest that the extension of the main Palos Verdes Hills anticline beneath San Pedro Bay has resulted in uplift of the Lakewood and San Pedro formations, and possibly exposed them to the ocean floor south of the breakwater (Stevenson, et al 1958, Crouch, 1954, and Moore, 1954). Water levels in the Silverado aquifer, however, indicate little or no hydraulic continuity with the ocean beneath San Pedro Bay. The significance of this data is not clear, since no subsurface information is available seaward of the Wilmington oil field. It is not known, therefore, whether aquifers deeper than the Gaspur and above the Silverado are in hydraulic continuity with the ocean in San Pedro Bay.

CHAPTER VI. DESCRIPTION OF GROUND WATER BASINS

This chapter describes the ground water basins in the Coastal Plain of Los Angeles County and discusses the occurrence and movement of ground water within each basin. Information regarding geologic features presented in earlier chapters is summarized here for each ground water basin to show what effect these features have on ground water flow into, through, and out of each basin. The relationships between the geologic features and the occurrence and movement of ground water as discussed in this chapter are intended to clarify the geologic setting of the area for future studies of hydrology, water quality, and problems involving the use of ground water.

Basin Boundaries

The ground water basin as herein used is defined as the area underlain by one or more permeable formations capable of furnishing a substantial water supply. It does not necessarily coincide with the surface drainage basins and is usually smaller in size because the essentially nonwater-bearing hills and mountains of the surface drainage basin (watershed) are excluded. Ground water basins are separated from adjacent basins by geologic features such as nonwater-bearing rock, faults, or other geologic structures which impede ground water movement, and by natural or artificial mounds or divides in the water table or piezometric surface. Geologic features generally establish well defined, fixed boundaries while ground water mounds are subject to change in time, particularly with changes in the development and use of ground water. However, both of these types of boundaries do define limits of ground water movement.

Ground water basins also have been arbitrarily separated along political boundaries or surface features such as along topographic divides and across narrow gaps through a range of mountains or series of hills. Such arbitrary divisions may be useful but they do not really define the limit of ground water basins nor its movement as do geologic features. In many cases, the use of surface features to delimit a ground water basin has simplified hydrologic analysis, but this is seldom the case when political boundaries have been used.

The Coastal Plain of Los Angeles County consists mainly of unconsolidated sediments or alluvium underlain by and bounded on the north and east by essentially bedrock. On the west and south it is bounded by the Pacific Ocean. Ground water is stored within the interstices of these unconsolidated sediments and in the cracks or fractures of the nonwater-bearing rocks which bound the area.

The coastal plain has been divided into four ground water basins by geological and surface features. Two of these four ground water basins are southwest and two are northeast of the series of low hills formed by the folds and faults of the Newport-Inglewood uplift. The Santa Monica Basin ("West Coast Plain - North", Calif. D. W. R. 1934) and the West Coast Basin occupy what Mendenhall (1905b) called the "Western Coastal Plain" west and southwest of the Newport-Inglewood uplift (Plate 2). East and northeast of the Newport-Inglewood uplift are the Hollywood and Central Basins (Plate 2), which Mendenhall (1905a) considered together as the "Central Coastal Plain of Southern California".

The Santa Monica Basin is the northernmost of the two basins southwest of the Newport-Inglewood uplift; it extends south from the Santa

Monica Mountains to the Ballona Escarpment between the uplift and the Pacific Ocean. The West Coast Basin extends southeast to the Palos Verdes Hills, San Pedro Bay, and Orange County. Although the Santa Monica and West Coast Basins have been divided at the Ballona Escarpment, the escarpment does not signify any geologic discontinuity in the water-bearing sediments. Rather, the separation was based on the existence of a ground water mound developed at this location as a result of ground water extractions. This ground water mound was carefully defined in the Report of Referee on the West Coast Basin (Calif. D. W. R. 1952a). The Newport-Inglewood uplift, which bounds these basins on the east, is a series of geologic features that exerts considerable influence on ground water movement along much of its length.

The Hollywood Basin is located south of the Santa Monica Mountains and east of the Newport-Inglewood uplift. It extends eastward to the Elysian Hills and south to the La Brea high, a complex subsurface structural feature. The Central Basin borders the Hollywood Basin on the south and occupies the rest of the Coastal Plain of Los Angeles County east of the Newport-Inglewood uplift. Historically, ground water moved from the Hollywood Basin across the La Brea high into the Central Basin. However, under present conditions, ground water levels are lower than the dome of this high so that it currently represents a barrier to ground water movement along the eastern section of the southern boundary. This feature plunges steeply at its western extremity, and the San Pedro formation is continuous from the Central Basin into the Hollywood Basin around the warped slope formed by the plunging anticline. A pumping depression or trough, developed in the vicinity of Culver City as the result of ground water extractions, now intercepts all flow from the Hollywood Basin, and has resulted in a ground water divide in the northern part of the Central Basin.

The southeast boundary of the Central Basin coincides with the Los Angeles-Orange County line. This boundary was originally defined (Calif. D. W. R. 1934) on the basis of a ground water mound generally paralleling the county line. Four areas are identified for descriptive purposes within the Central Basin: the Los Angeles and Montebello Forebay Areas, the Whittier Area, and the Central Basin Pressure Area (Plate 2). The boundaries of these areas are as described in Bulletin No. 45 (Calif. D. W. R. 1934). The forebay areas extend south from the Los Angeles and Whittier Narrows, two breaks in the hills which form the northern boundary of the basin. The Whittier area (formerly part of the La Habra Basin) is located in the northeastern part of the Central Basin, east of the Montebello Forebay Area. The Central Basin Pressure Area includes the rest of the Central Basin to the west and south of the other three areas.

Another basin, the "Los Angeles Narrows Basin" (Calif. D. W. R. 1934), was formerly recognized as part of the Coastal Plain of Los Angeles County. It extended from the Central Basin north to the San Fernando Basin, with an arm extending eastward along the Arroyo Seco into the San Gabriel Valley. Recent investigations have shown that the Los Angeles Narrows Basin should be divided; one part should be included with the San Fernando Basin and the remainder with the Central Basin. This change has been followed in this report and the boundary of the coastal plain in the vicinity of the Los Angeles Narrows was placed just north of and parallel to Figueroa Street across the narrowest portion of the alluvial fill. The area south of this new line and eastward along the Arroyo Seco is now included within the Central Basin.

Ground Water Occurrence

Poland (1948 and 1959a) divided the ground water contained in the alluvial sediments of the Coastal Plain of Los Angeles County into three categories, each of which may appear in any single ground water basin. In downward succession these are: (1) a body of shallow, unconfined, semiperched water which occurs in the upper part of the alluvial deposits in the Downey Plain and the Torrance Plain, (2) the principal body of fresh ground water, which occurs chiefly in deposits of Recent and Pleistocene age, and possibly in underlying Pliocene rocks, and (3) saline water underlying the principal fresh water body throughout the area.

The only use at the present time of the saline water underlying the coastal plain has been to repressurize areas where oil has been extracted. Since the primary interest is in the fresh ground water resources of the area, this chapter considers Poland's first and second categories of ground water, and omits further consideration of the saline waters.

Ground Water Movement

In all ground water basins, water moves from the point or points of recharge through the basin to the point or points of discharge. Ground water flow occurs because of differentials in pressure between the points of recharge and discharge, which establish a hydraulic gradient in the water surface. This flow will continue in one or more directions until the flow path is blocked by some structural barrier (i.e., fault, fold, unconformity, or a physical characteristic of the aquifer) or until the gradient of the water surface is altered by withdrawals or artificial recharge. The basin will generally discharge into another basin, or into a river, lake, or the ocean.

The ground water basins in the coastal plain are recharged by surface and subsurface inflow from the hills and mountains bordering the areas and from the adjacent San Gabriel and San Fernando Valleys, by downward percolation of the waters from the major streams crossing the area, by direct percolation of precipitation and other applied water, and by artificial recharge of either local or imported water through both spreading the water in specially prepared basins where it is impounded and allowed to percolate and injecting the water into wells.

The extensive paving of streets and construction of urban communities has greatly reduced the areas open to direct percolation of precipitation and applied water. Extension of sewer systems discharging through ocean outfalls, improvement in surface drains, and the lining of river channels to facilitate the runoff of floodwaters have all resulted in less water percolating into the ground water basins. In recent years the expansion of artificial recharge programs has tended to offset these reductions in the natural recharge to the ground waters of the coastal plain.

Discharge from the coastal plain under natural conditions has been to the Pacific Ocean. However, the increased withdrawals of ground water from the area, combined with the lower rate of replenishment during recent years, have reversed normal gradients as evidenced by sea water moving inland in the coastal portions of the aquifers and by the presence of "troughs" or pumping depressions in the ground water surface. At the present time, there is little subsurface outflow to the ocean.

Evapo-transpiration processes account for a minor amount of the ground water naturally discharged from the basins. The major discharge of ground water is presently by pumpage and eventual discharge to the ocean through sewers of the amount not consumptively used.

Rates of flow of ground water within the basins depend not only on the hydraulic gradient, but also on the cross-sectional area and permeability of the sediments. A very useful term in determining rates of flow is the coefficient of transmissibility, which is defined as coefficient of permeability multiplied by the saturated thickness, usually in gallons per day per foot of width or in cubic feet per second per foot of width. About 40 well tests have been conducted in the Coastal Plain of Los Angeles County to determine coefficients of transmissibility and storage. Selected references used in these computations are included on Page 1-10 of Attachment 1. Results of the tests are summarized in Table C in Attachment 2. In a few cases, it was possible to compute vertical permeability of the overlying aquiclude as indicated in this table.

Using results of the transmissibility tests, average values for permeability were computed and assigned to drillers logs. This procedure is discussed in Attachment 2 of this report and the values are shown in Table D. Using all well tests and several hundred well logs, transmissibility was then estimated for the major aquifers. Lines of equal transmissibility of the aquifers were generalized and drawn on Plates 26A through 26H. The values for all aquifers were later combined as shown on Plate 26I which is very generalized but is convenient to use in many hydrologic and operational studies.

Ground Water Storage

When discharge or outflow from a basin exceeds recharge or inflow, ground water is removed from storage in the basin. The amount of water in storage depends on the volume of sediments and their specific yield. Specific yield is defined as the ratio between the volume of stored water which a saturated sample of material will yield by gravity and the volume of that sample; it is customarily expressed in percent.

Specific yield values for the sedimentary deposits of Los Angeles County are given in Attachment 2, Table A. These specific yield values were compiled from available data, including work done by the State Water Rights Board for the San Fernando Valley Reference, and from Bulletin 45 (Calif. D. W. R. 1934). They were also checked against figures obtained from well tests but no new determinations were made during this investigation. Specific yield values are multiplied by the thickness and areal extent of the water-bearing sediments to determine the total storage capacity of these sediments. The variation in specific yield value over the coastal plain by elevational increments that were used in computations of storage are tabulated in Table B, Attachment 2.

Changes in the amount of ground water in storage in the ground water basins in the Coastal Plain of Los Angeles County have occurred mainly in the forebay areas. However, changes in storage have also occurred in other free ground water areas and in the pressure areas where water levels have been drawn below the base of the upper confining aquiclude. Additional limited changes of storage have occurred by dewatering of the confining aquicludes. The areas where changes in storage have occurred are discussed in the description of the individual basins; however, because of the general widespread nature, changes of storage in the Bellflower aquiclude are not delineated. Within the area as a whole, total storage to the base of the Sunnyside aquifer, or to the Silverado aquifer where the Sunnyside is missing, is approximately 22 million acre-feet. Ground water storage depletion since 1904 is about 1,200,000 acre-feet and the storage between historical high water levels which occurred in 1904 and sea level is about 1,600,000 acre-feet.

The discussion which follows treats the geology of each basin and its relation to ground water, the means by which the aquifers present are replenished, the areas of confined water, the barriers to ground water movement within or between basins, and the movement of water in each basin.

Santa Monica Basin

The Santa Monica Basin is bounded by the Santa Monica Mountains on the north and the Ballona Escarpment on the south. It extends eastward from the Pacific Ocean to the Inglewood fault (see Plate 2). This area was originally considered a part of the West Coast Basin, which now is limited to the area immediately south of the Santa Monica Basin. The Santa Monica Basin has also been referred to in prior publications as "West Basin Northern Area" (Calif. D. W. R. 1934); "West Coastal Plain - North" (Calif. D. W. R. 1947); and "West Coast Basin - North" (Calif. D. W. R. 1958a).

The majority of the water wells in the Santa Monica Basin lie south of Santa Monica Boulevard in an area covered by Recent alluvium

(Plate 3B). North and northwest of Santa Monica Boulevard, where the Lakewood formation is exposed on the surface, and in the area covered by Older Dune Sand of late Pleistocene age, comparatively few wells have been drilled and little data are available. The area north of the Baldwin Hills, between the Overland Avenue and Inglewood faults (shown on Plate 3B), is also deficient in water well log data; however, oil well and electric log data indicate that fresh water is present in the undifferentiated Lakewood, San Pedro, and Pliocene formations. While no aquifers or aquicludes have been defined in either the northwest or northeast parts of the Santa Monica Basin, they do exist there.

Geologic Features

The Santa Monica Basin is overlain by six different physiographic features: Santa Monica Plain, Ocean Park Plain, Sawtelle Plain, part of the Beverly Hills, Ballona Gap, and the northern tip of the Baldwin Hills. These features are shown on Plate 2 and discussed in detail in Chapter III.

Recent alluvium, the Lakewood and San Pedro formations, and some older sediments have been identified in the Santa Monica Basin (Plate 3B). The known aquicludes and aquifers, however, are restricted to the Recent alluvium and the San Pedro formation. The Recent alluvium covers the Sawtelle Plain and Ballona Gap where it attains a maximum thickness of about 90 feet. Included within these sediments is a portion of the Bellflower aquiclude and the Ballona aquifer.

The Bellflower aquiclude (Plate 9B) within the Recent alluvium consists of 20 to 40 feet of clay and sandy clay extending to a maximum depth of about 50 feet (40 feet below sea level) below the surface (Plate 8B). It is also quite probable that the Bellflower aquiclude is present in the undifferentiated Lakewood formation in the Ocean Park Plain, the Santa Monica Plain, and the Beverly Hills area where it would partially restrict percolation of surface water.

The Ballona aquifer, called the "50-foot gravel" in a prior report (Calif. D. W. R. 1952a), consists of 30 to 50 feet of gravel and coarse sand (Plate 11B) and has a maximum depth of 70 feet (60 feet below sea level) below ground surface (Plate 10B).

The Lakewood formation and the Older Dune Sand of late Pleistocene age cover most of the northern half of the Santa Monica Basin. The Lakewood formation includes the weathered, reddish-brown continental deposits covering the Santa Monica Plain and the sands, clays and conglomerates of marine origin that form the Beverly Hills. The Older Dune Sand consists of sand and silt washed free of clay, which, according to Hoots (1931), "...probably represents sand bars and shore-line bluffs that were developed when the ocean stood at a higher level with relation to the land." These Older Dune Sands were later modified by wind action. The thickness of the Lakewood formation and the dune sand is uncertain in this basin, but it is known that the Lakewood formation thins out in the northern part of the basin where it overlies the older rocks of the Santa Monica Mountains.

The San Pedro formation is found beneath the Recent alluvium over the southern half of the Santa Monica Basin with no evidence of intervening Lakewood materials. In the northern part of the basin, the Lakewood formation is present and in the westerly portion appears to directly overlie Pliocene and older sediments with the San Pedro formation apparently missing. In the northeastern part of the basin, oil well and fossil data indicate that the San Pedro formation is at least 500 feet thick. In the Ballona Gap area available data indicate that the San Pedro formation has a thickness of about 300 feet.

The Silverado aquifer is the only member of the San Pedro formation identified in the Santa Monica Basin. It is mainly sand and gravel, with a small amount of clay. It ranges from 100 to 280 feet in thickness, and extends downward to elevation minus 420 feet, 450 feet below the ground surface (Plate 6D, Section G-G').

The San Pedro formation is underlain by sediments of Pliocene age in the southern and northeastern parts of the Santa Monica Basin. Oil well electric logs indicate that fresh water extends down several hundred feet below the base of the San Pedro formation in the western part of the Ballona Gap Area. In the northeastern part of the basin available oil well electric logs indicate that the San Pedro formation is underlain by saline water-bearing Pliocene sediments. Current subsurface work by oil companies in the northwestern portion of the basin may reveal the nature of the fresh water-bearing sediments there. Available outcrops suggest that the geology of the San Pedro and older formations is complex in that area. Plate 24, "Lines of Equal Elevation on the Base of Fresh Water-Bearing Sediments", indicate the spotty nature of the data in this basin by the limited number of elevations shown for this basin.

The major structural features of the Santa Monica Basin are the unconformity in the northern part, which brings the thin Lakewood formation into contact with the underlying Pliocene and Miocene deposits, and a number of faults in the area. Three of these faults, the Inglewood, Overland Avenue and Charnock faults, (Plate 3B) have been described previously. Several other faults in the basin have been reported in previous literature. Hoots (1931) shows a small fault extending into the basin near Potrero Canyon. In the "Guide to Geology and Oil Fields of the Los Angeles and Ventura Regions, Barbat (1958)", postulates an east-west fault system extending from north of Santa Monica to a point about four miles southeasterly of the Los Angeles civic center. Poland (1959a) also shows a small east-west fault located east of Santa Monica, which may possibly be related to Barbat's fault system. These faults described by Barbat and Poland are not shown on the geologic map in this report because there is no clear evidence that they affect water-bearing sediments.

The Inglewood fault, which forms the eastern boundary of the Santa Monica Basin, appears to be a barrier to the movement of ground water in the area between the Baldwin Hills and a point about one-half mile south of Santa Monica Boulevard. North of this point the presence of the fault is largely conjectural; electric logs of oil wells show a deep zone of fresh water west of where the Inglewood fault would be if it continued northward. Water level records in these sediments suggest that in this area the fault is either not present or does not act as a barrier.

The Overland Avenue fault in Ballona Gap also appears to act as a barrier to ground water movement since ground water levels on the east side of the fault are much higher than on the west side.

The Charnock fault, the westernmost of the three principal faults mentioned, appears to affect only slightly ground water movement in the Santa Monica Basin. It cuts the Silverado aquifer, which shows a displacement of about 180 feet (Plate 6A, Section A-A'), but leaves the water-bearing sediments still in juxtaposition. Ground water movement across the fault is still possible, though ground water levels are higher on the west side of the fault.

Occurrence of Ground Water

Ground water occurs in all sediments of the Santa Monica Basin from Recent alluvium to deposits of Miocene age. Water well information is available only where aquifers have been identified in the Sawtelle Plain and Ballona Gap areas. In these two areas ground water is found in deposits of Recent and lower Pleistocene age. In the area north of the Baldwin Hills between the Overland Avenue and Inglewood faults (Plate 3B), oil well data and electric logs indicate the presence of water in the undifferentiated Pleistocene and older formations as well.

Water levels in the Recent alluvium in the Sawtelle Plain are much higher than water levels in wells that penetrate the older sediments, suggesting that a perched or semiperched aquifer exists in this area.

Replenishment of ground water in the Santa Monica Basin is mainly by percolation of precipitation through sandy phases of the Bellflower aquiclude, the Lakewood formation and the Older Dune Sand, and by percolation of surface runoff into the basin from the mountains to the north. The Inglewood fault appears to inhibit replenishment from the Central Basin to the east. It is possible, however, that ground water does move between the Santa Monica and Hollywood Basins around the north end of the Inglewood fault.

Ground water in the Santa Monica Basin moves mainly toward the south, in the direction of Ballona Gap (Los Angeles County Flood Control District, 1958). Partial degradation of the ground water underlying the western part of Ballona Gap has taken place over the years (Calif. D. W. R.

1958b) as evidenced by an increase in the chloride content. Part of the degradation may be due to sea-water intrusion into the aquifers because water levels have fallen below sea level. However, north of Ballona Creek in the City of Santa Monica, available data suggest that minor subsurface flow toward the ocean may occur.

Aquifers in Santa Monica Basin generally have transmissibility rates less than about 100,000 gallons per day per foot. In this basin, the Silverado aquifer has a maximum transmissibility rate of about 150,000 (see Plate 26G "Lines of Equal Transmissibility of the Silverado Aquifer"), and the Ballona aquifer has a maximum transmissibility rate of about 70,000 (see Plate 26A, "Lines of Equal Transmissibility of the Gaspur and Ballona Aquifers"). Because thickness of aquifers is poorly known in the north portion of the basin, transmissibility rates are not shown there, but they appear to be increasing in that direction. However, the rates would decrease as the Santa Monica Mountains are approached and the aquifers become thinner.

Changes in storage and free ground water conditions could possibly occur along the north edge of the Baldwin Hills and the south edge of the Santa Monica Mountains where the Lakewood and San Pedro formations crop out at the surface. Free ground water conditions also may exist near the coast in the Ballona Gap area where the Bellflower aquiclude is missing.

Total storage to the base of the Sunnyside aquifer, or Silverado aquifer where the Sunnyside is missing, amounts to about 1,100,000 acre-feet. Historically utilized storage is difficult to determine because of the paucity of information available. It probably has amounted to about 38,000 acre-feet since 1904, and occurs in both shallow and deep aquifers. Storage between historical high water levels which occurred in 1904 and sea level is about 36,000 acre-feet.

West Coast Basin

The West Coast Basin extends southwesterly from the Newport-Inglewood uplift to Santa Monica Bay, to the drainage divide on the Palos Verdes Hills, and to San Pedro Bay. It extends from the Ballona Escarpment and Baldwin Hills on the northwest to the Los Angeles-Orange County line on the southeast. The basin boundaries are defined in the Report of Referee (Calif. D.W.R. 1952a).

Mendenhall (1905b) referred to this area as the "Western Coastal Plain Region". In Bulletin No. 45 (Calif. D.W.R. 1934) Eckis used the term "West Basin - Southern Area" for the West Coast Basin, which was slightly modified to "West Coastal Plain - South" in Bulletin No. 53 (Calif. D.W.R. 1947). The term "West Coast Basin" was officially accepted in the Report of Referee (Calif. D.W.R. 1952a, and has remained in use from that time.

Plates 6A and 6G and plates showing lines of equal elevation and lines of equal thickness of those aquifers in the West Coast Basin were based mainly on data taken from the Report of Referee (Calif. DWR, 1952a). However, in some areas, particularly along the coast line, the subsurface geology was modified pursuant to unpublished information obtained from the Los Angeles County Flood Control District. This district has undertaken extensive subsurface geologic exploration in connection with their studies of sea water barrier construction along Santa Monica Bay that will provide valuable detailed information on the geology of these areas. In the Long Beach Plain data are seriously lacking because only a few wells have been drilled.

Geologic Features

Physiographic features of the West Coast Basin are the Torrance and Long Beach Plains, the El Segundo Sand Hills, the Dominguez and Alamitos Gaps, and portions of the Baldwin Hills, the Rosecrans Hills, Dominguez Hill, Signal Hill, and the Palos Verdes Hills (Plate 2). The continuity of the Newport-Inglewood belt of hills, which flanks the West Coast Basin on the northeast, is broken by Dominguez and Alamitos Gaps, which are stream-cut channels eroded and backfilled by ancestral rivers. Most of the basin consists of a gentle, poorly drained plain flanked by the partly eroded highland areas of the Newport-Inglewood belt of hills and the heavily eroded Palos Verdes Hills. Toward Santa Monica Bay, a wide belt of sand dunes, containing many closed depressions, form the El Segundo Sand Hills.

Sediments of the Recent Series and the Lakewood and San Pedro formations of the Pleistocene Series have been identified within the West Coast Basin. The principal aquifers in these series are discussed below.

The Recent Series has two main divisions - the Active Dune Sand and the Recent alluvium. The Active Dune Sand occurs along the coast bordering Santa Monica Bay and extends inland for a maximum distance of about one-half mile. Some of these dunes are 70 feet thick. The Recent alluvium occurs mainly in the Gardena area and within Dominguez Gap, with a lobe extending northwesterly from Dominguez Gap between Dominguez Channel and Dominguez Hill. Another small sinuous area of alluvium extends into Bixby Slough from San Pedro Harbor. Irregular patches also occur south of Torrance. Members of the Recent alluvium include the Semiperched aquifer, the Bellflower aquiclude, the Gaspur aquifer, and miscellaneous beach, playa lake, and lagoonal marshland deposits.

The Recent portion of the Semiperched aquifer occurs only in Dominguez and Alamitos Gaps. It consists of sand, silty sand, silt and clay. The Semiperched aquifer can be detected in well logs, but water level measurements have been obtained from only a few test holes. Available evidence indicates that water levels in the Semiperched aquifer are generally above water levels in the Gaspur aquifer. Water in the Semiperched aquifer is generally of poor quality.

The Recent part of the Bellflower aquiclude occurs in Dominguez Gap where it overlies the Gaspur aquifer, and ranges in thickness from 40 to 80 feet (Plate 9B). The upper part of the aquiclude is sandy silt or sandy clay.

The Gaspur aquifer, entirely of Recent age, occurs only in Dominguez Gap. It has been slightly deformed over the Cherry Hill fault in such a manner that its base rises to an elevation of 80 feet below sea level. It reaches a maximum known depth of about 140 feet below sea level near Terminal Island (Plate 10B). Through the gap it is 40 to 80 feet thick (see Plate 11B). These coarse sands and gravels are confined and produce large quantities of water. Extensive sea-water intrusion into this aquifer is evidence that it is exposed to the ocean. The connection with the ocean may occur some distance offshore or may be through permeable overlying materials closer to shore or possibly both.

Upper Pleistocene deposits include the Older Dune Sand and the Lakewood formation. The Older Dune Sand occurs in a band from about three to four miles wide inland from Santa Monica Bay, extending from the Ballona Escarpment to the Torrance area. It forms the major part of the El Segundo

Sand Hills. Since deposition, the Older Dune Sand has been tilted, weathered, eroded, and further altered by cementation and leaching processes. Surface water percolates into the dunes from closed depressions after heavy rains. Ground water is not, however, extracted from the Older Dune Sand although some perched water bodies may occur.

Divisions of the Lakewood formation in the West Coast Basin include the Semiperched aquifer, the Bellflower aquiclude, the Gardena aquifer, and the Gage aquifer. Those deposits previously known as Terrace Cover and the Palos Verdes sand constitute that part of the Semiperched aquifer that is of late Pleistocene age. These sediments may have been deposited at the same time as the Artesia-Exposition aquifers in the Central Basin.

Underlying both the Older Dune Sand and the Semiperched aquifer is that part of the Bellflower aquiclude which is of late Pleistocene age; it has been previously called the fine-grained phase of the Unnamed Upper Pleistocene Deposits. In the West Coast Basin, the Bellflower aquiclude overlies most of the Newport-Ingleood uplift and Torrance Plain though it is missing over the Baldwin Hills. It reaches a maximum depth of 140 feet below sea level (Plate 8B) and ranges up to 200 feet in thickness (Plate 9B). This heterogeneous mixture of continental, marine, and wind-blown sediments is generally fine-grained, consisting of silty clays and clays. It also contains lenses of sandy or gravelly clays which may be permeable enough to permit water to move vertically downward from the overlying Semiperched aquifer to the underlying aquifers. It is not significant as a source of ground water. The Gardens and Gage aquifers are constituted of part of those sediments previously referred to as Unnamed Upper Pleistocene Deposits.

The Gardena aquifer extends westward from Lynwood over the Newport-Inglewood uplift to Redondo Beach. It was deposited by an ancestral stream during a rise in sea level and has since been folded over the uplift. The aquifer is composed of sand and gravel with a few discontinuous lenses of sandy silt. It reaches a maximum depth of 200 feet below sea level (Plate 12B) and is as much as 160 feet in thickness (Plate 13B). Permeability is high in the Gardena aquifer, as evidenced by the many wells which tap this aquifer near the City of Gardena. Yields are high and range from 100 to 1,300 gallons per minute. Recharge to the aquifer occurs primarily in the Downey Plain and water is transmitted through the aquifer into the West Coast Basin. Some additional recharge is received by the Gardena aquifer from the overlying Semiperched aquifer and Active Dune Sand, and from the Gage aquifer, with which it is in hydraulic continuity.

The Gage aquifer (previously known as the "200-foot sand") extends over most of the West Coast Basin except for the Long Beach Plain. It is merged with the underlying aquifers near Torrance and south of the Ballona Escarpment along Santa Monica Bay. Except for local areas the Gage aquifer is confined by the Bellflower aquiclude. In the vicinity of Torrance, the Gage aquifer reaches a depth of 250 feet below sea level (Plate 12B) and attains a thickness of 160 feet (Plate 13B). It is composed chiefly of sand with minor amounts of gravel and thin beds of silt and clay. The aquifer exhibits moderate to low permeability and therefore is of secondary importance as a ground water producer in the West Coast Basin. The few wells extracting from this aquifer supply water for domestic and irrigation purposes.

Lower Pleistocene deposits are represented in the West Coast Basin by the San Pedro formation, which is of marine origin. The San Pedro formation includes two main aquifers, the Lynwood and the Silverado. Outcrops of the San Pedro formation occur on the Baldwin Hills, along the northeastern margin of the Palos Verdes Hills, and on Signal Hill. Portions of the Santa Monica and San Pedro shelves in the ocean are underlain by it. The San Pedro formation thickens along the Gardena syncline from 400 feet near Ballona Gap to more than a thousand feet in Dominguez Gap. It has been offset by the Charnock, Inglewood, Potrero, Avalon-Compton, Cherry Hill and Northeast Flank faults.

The uppermost aquifer of the San Pedro formation in West Coast Basin, the Lynwood aquifer (previously known as the "400-foot gravel"), is composed, in the northern and central parts of the basin, of sand and gravel with lesser amounts of sandy silt, silt, and clay. South of Gardena the gravel is missing and the aquifer consists mainly of sand and sandy silt. The Lynwood aquifer attains its maximum thickness of 200 feet one mile west of the intersection of Alameda Street and Sepulveda Boulevard (Plate 19B). Just one mile northwest of Gardena it reaches its greatest depth, 550 feet below sea level (Plate 18B). The Lynwood aquifer is confined throughout the West Coast Basin except in those areas where it merges with the overlying Gage aquifer (Plate 18B). It also merges with the underlying Silverado aquifer along Santa Monica Bay and along the Newport-Inglewood uplift.

About ten percent of the wells in West Coast Basin are perforated in the Lynwood aquifer. These wells are located primarily in the Torrance, Compton, and Inglewood areas. Few of them draw water solely from the Lynwood aquifer because they are usually perforated in other aquifers as well. Yields of 500 and 600 gallons per minute have been reported.

Deposits of the Silverado aquifer, the lower defined aquifer of the San Pedro Formation in the West Coast Basin, consist of fine to coarse-grained, blue-grey sands and gravels that are continuous over most of the area but are interbedded in some places with discontinuous layers of relatively impermeable sandy silt, silt, and clay. These highly permeable marine deposits reach a maximum thickness of 500 feet (Plate 21B) between the Wilmington anticline and the Cherry Hill fault. The Silverado aquifer reaches its maximum depth at elevation 1,200 feet below sea level (Plate 20B), in Dominguez Gap. It also is most permeable in this area. The Silverado aquifer is merged with the overlying Lynwood aquifer along the coast from Ballona Gap to Redondo Beach, along the north flank of the Palos Verdes Hills, beneath the central and southern part of the Rosecrans Hills and the northern part of Dominguez Hill (Plate 20B). Near Redondo Beach and Hermosa Beach, the merged Lynwood-Silverado aquifers are in hydraulic continuity with the overlying Gardena aquifer; from Hermosa Beach to Ballona Gap, and along the north flank of the Palos Verdes Hills they are in continuity with the Gage aquifer.

Beneath the Silverado aquifer in some parts of the West Coast Basin are 500 to 700 feet of fresh water-bearing materials of the San Pedro and probable Pico formations which have not been identified as an aquifer or aquifers. The approximate elevation of these fresh water-bearing materials is shown on Plate 24B. Along the coast from Redondo Beach to the Ballona Escarpment these deposits are coarse sands and gravels which correspond in age and thickness to the Sunnyside aquifer in the Central Basin. Over the rest of the basin these deposits are fine-grained and act as an aquiclude. The upper division of the Pico formation consists of relatively impermeable micaceous silt and clay members interbedded with fresh water sands and lenses of gravel. Water contained in deeper Pliocene sediments is mostly saline.

As previously stated, the Newport-Inglewood uplift exerts a partial barrier effect on ground water movement from the Central Basin into the West Coast Basin, especially in the Pleistocene aquifers, by offsetting, elevating, or thinning of the aquifers which pass over it. Lithologic changes and thinning across the uplift have been due primarily to movement during deposition of aquifers and the faulting and elevation which followed. Because of its elevation this area apparently has acted as a boundary for the Artesia-Exposition, Hollydale, and Jefferson aquifers during their deposition by controlling alluviation and restricting the aquifers to the Central Basin.

Pleistocene and older formations that continue across the Newport-Inglewood uplift into West Coast Basin are sharply downwarped into a complex regional basin structure, the Hawthorne-Long Beach depression immediately to the west of the uplift. Many secondary structures interrupt the regularity of this regional downwarp. One of these secondary structures is the Gardena syncline, which parallels the Newport-Inglewood uplift. It plunges toward the southeast and is faulted in the northern part of the West Coast Basin by the Charnock fault. West of the Charnock fault, the water-bearing deposits rise toward the ocean with a gentle slope, while in the southern portion of the West Coast Basin they are deformed over the Torrance, Wilmington, and Gaffey anticlines and downwarped by the Gaffey syncline. Farther to the southwest the water-bearing materials lap onto the northeast slope of the Palos Verdes Hills, a structural highland composed of Miocene and older rocks.

Occurrence of Ground Water

Ground water occurs in Recent and Pleistocene aquifers throughout the West Coast Basin, and some fresh water occurs in the underlying Pliocene sediments. The Semiperched aquifer of both Recent and late Pleistocene age is unconfined. The water in underlying aquifers is confined throughout most of the basin, though the Gage and Gardena aquifers are unconfined where water levels have dropped below the Bellflower aquiclude on the Newport-Inglewood belt of hills and in the northwest corner of the basin.

The major fresh water replenishment to the basin occurs by subsurface flow across the Newport-Inglewood uplift, also subsurface flows which have become increasingly saline occur from the seaward extensions of the aquifers under the influence of a landward hydraulic gradient. The merged Silverado-Lynwood-Gardena-Gage aquifers are in hydraulic continuity with Santa Monica Bay, while only the Gaspur aquifer appears to be in hydraulic continuity with San Pedro Bay. Subsurface flow occurs between the Santa Monica and West Coast Basins, with the direction of flow depending on the direction of the hydraulic gradient.

Subsurface flow across the Newport-Inglewood uplift is controlled by the difference in water levels between the Central Basin and West Coast Basin (which is itself influenced by the withdrawals, outflow, and replenishment measures taken in either basin), by the dewatering of the aquifers along the crest of the uplift, and by the degree to which the faults and folds act as barriers to ground water flow. The barrier effect may depend on cementation along fault zones, lithologic changes which in turn affect permeability, and the varying thicknesses of aquifers over the uplift.

Subsurface inflow across the Newport-Inglewood uplift occurs in the Gaspur aquifer of Recent age and through the Gage, Gardena, Lynwood, and Silverado aquifers of late and early Pleistocene age.

The Baldwin Hills are an effective barrier to ground water movement. South of the Baldwin Hills, the Inglewood fault, in conjunction with the Potrero fault and other transverse faults associated with it, acts as a barrier, which, although relatively impervious, is not completely water tight. The Lynwood aquifer has not been delineated in this fault zone because of insufficient data. The Silverado aquifer continues through the most southerly block of this fault zone.

From the physical characteristics of the aquifers extending across the Rosecrans anticline, a barrier effect would not be expected; however, a differential in water levels does exist across the anticline indicating at least a partial structural barrier effect.

South of the Rosecrans anticline the Avalon-Compton fault acts as a barrier to ground water movement only in the deeper lower Pleistocene deposits. The younger, overlying Lynwood aquifer and aquifers of the Lakewood formation extend across this barrier without offset.

Both the Lakewood and San Pedro formations continue without interruption over the Dominguez anticline, though wells producing from the San Pedro formation show a discontinuity in water levels. Within Dominguez Gap, no barrier effects are found in the Gaspur and Semiperched aquifers. The Lakewood formation also appears to be continuous, although warped, across the Cherry Hill fault. The San Pedro formation is in partial continuity across the fault but wells utilizing the Silverado aquifer show a barrier effect.

The Cherry Hill fault, along the west side of Signal Hill, has offset all aquifers. However, ground water movement across the fault is maintained and hydraulic continuity preserved by entirely different aquifers abutting against each other on opposite sides of the fault. Southeast of Signal Hill, the Cherry Hill and Reservoir Hill faults act as barriers to ground water movement in all aquifers. Poland (1959a), states that the barrier effect on Signal Hill may be interrupted by a gap 1,000 feet wide between the Northeast Flank and Reservoir Hill faults, an area in which sea-water intrusion may occur.

Within Alamitos Gap, the Seal Beach fault does not sever hydraulic communication within the Recent deposits, which extend to a depth of about 100 feet. Below this depth, the fault forms a substantial barrier to ground water movement through the aquifers of the Lakewood and San Pedro formations, which rise unconformably toward the fault on the inland side. Seaward from the Seal Beach fault, the Lakewood formation is absent, and aquifers of the San Pedro formation directly underlie Recent deposits.

Minor replenishment to the West Coast Basin occurs in the form of surface inflow from both the Los Angeles and San Gabriel Rivers which cross the Newport-Inglewood uplift through Dominguez and Alamitos Gaps, respectively. However, lining of the Los Angeles River in the West Coast Basin north of Willow Street (Sepulveda Boulevard) was completed in 1956, thereby eliminating recharge to the Basin in this area. Between Willow Street and Terminal Island, the bed of Los Angeles River is not lined and has a sandy bottom with riprap sides. Because the channel section and the wetted perimeter have been reduced, infiltration through the river sands has decreased.

The San Gabriel River has not been lined although a program of such lining has been proposed. In Alamitos Gap, therefore, some infiltration of stream flow still may occur into the Recent alluvial deposits. However, because the reach between the Seal Beach fault and the Pacific Ocean is only one and one-quarter miles in length, the quantity of infiltration involved is probably minor.

Changes in ground water levels in the West Coast Basin do not generally reflect seasonal variations of precipitation. Therefore it is believed that the annual quantity of recharge effected by percolation of precipitation is small.

Other sources of recharge by infiltration from the surface include return irrigation water from fields and lawns, industrial waters, oil field brines, and other applied surface waters. Poor surface drainage in the past resulted in large expanses of swamp and slough, but these conditions have been improved by the channelization of Dominguez Creek and improved street drainage. At the present time, some surface drainage still collects in the low areas until it disappears by slow infiltration or evapo-transpiration processes.

Near surface replenishment is from infiltration of cesspool effluent and leakage from water distribution systems. These surface and near surface waters are somewhat restricted from moving downward by the Bellflower aquiclude and therefore may remain within the Semiperched aquifer. Some of this water also moves downward through permeable sections of abandoned wells which may serve as conduits between aquifers. Improper abandonment of such wells needs to be restricted to prevent poor quality surface water from gaining access to the deeper horizons.

In the following discussion, the ground water movement throughout the West Coast Basin was derived from the most readily available ground water level contours which are reproduced in Appendix B, "Safe Yield Determinations", to Bulletin No. 104. Although "troughs" or "lows", which develop in both piezometric and free ground water areas, may migrate slightly from spring to fall in a given year, or from year to year, historical data from 1932 to the present show that the general pattern has not particularly changed.

In the spring of 1956, water levels of wells perforated in the Gaspur aquifer indicated ground water movement toward two pumping depressions in Dominguez Gap, one midway between the Cherry Hill fault and Long Beach Harbor and the other near Long Beach Harbor itself.

In 1959 subsurface inflow in the deeper aquifers occurred across the Ballona Escarpment from the Santa Monica Basin and moved southeasterly between the Charnock fault and the structures of the Newport-Inglewood uplift toward a pumping depression near Hawthorne. A general low or trough is aligned along the Gardena syncline and extends from Gardena southeastward toward Dominguez Gap. Piezometric levels reach a low elevation in the vicinity of Carson Street and Wilmington Avenue. Into this trough moves westerly flowing water which crosses the uplift between the Rosecrans anticline and the Avalon-Compton fault, and easterly flowing water from Redondo Beach and Hermosa Beach. A third major trough or pumping depression is centered just east of El Segundo. Water flows into it from that part of the coast between Manhattan Beach and the Ballona Escarpment.

Discharge of ground water from the basin under present conditions occurs primarily by pumping extractions. Some subsurface outflow has occurred historically to the north into the Santa Monica Basin and to the west and south to the ocean; however, with the prevailing below-sea-level water levels, the subsurface flow is into the basin and sea water has intruded along the coastline. Should the water levels be raised above sea level, subsurface outflow could once again occur.

Aquifers in West Coast Basin have extremely variable rates of transmissibility. The Silverado aquifer (Plate 26G) has the highest transmissibility rate, averaging about 150,000 gallons per day per foot of width with a maximum of about 400,000 gallons per day per foot near Torrance and near the intersection of Alameda and Sepulveda Boulevards. The other aquifers generally have lower transmissibility rates since they are thinner and have smaller grain sizes. The Gaspur (Plate 26A),Gage, and Gardena aquifers (Plate 26C) "Lines of Equal Transmissibility of the Gage and Gardena Aquifers", Lynwood aquifer (Plate 26F), "Lines of Equal Transmissibility of the Lynwood Aquifer" have transmissibility rates of about 50,000 to 100,000 gallons per day per foot, in West Coast Basin. In general, transmissibility rates near the ocean are lower than they are in the center of the basin. Although the combined transmissibility rates of all aquifers are low along some parts of the Newport-Inglewood uplift, they are relatively high in other portions, particularly in the Dominguez Gap north of Long Beach. This is shown on Plate 26I, "Generalized Lines of Equal Transmissibility of the Combined Aquifers."

Change in ground water storage occurs within the merged areas along the Newport-Inglewood uplift, near the Palos Verdes Hills, along the northwest corner of Torrance Plain, and to a minor extent within Alamitos and Dominguez Gaps. Change in ground water storage has also occurred in parts of the Semiperched aquifer and also the Bellflower aquiclude where piezometric levels have been lowered below its surface. Total storage to the base of the Silverado aquifer, the deepest aquifer delineated in the West Coast Basin, is about 6,500,000 acre-feet. Historically utilized storage since 1904 amounts to about 300,000 acre-feet. Most of this change in storage occurred in the Gage-Gardena aquifer, which is classified as a shallow aquifer. Small additional changes in storage have occurred in the deeper aquifers where they crop out along the northeastern side of the Palos Verdes Hills and along the southern slope of the Baldwin Hills. The storage capacity between the historical high water levels which occurred in 1904 and sea level is about 120,000 acre-feet.

Hollywood Basin

The Hollywood Basin extends from the Santa Monica Mountains southward to an arbitrary line which roughly parallels the crest of the La Brea high, a subsurface structural feature beneath the La Brea Plain. Its western and eastern boundaries are the Inglewood fault and the Elysian Hills, respectively (Plate 2). In Bulletin No. 45 (Calif. D.W.R. 1934) the name "Hollywood Basin" was first used for the area just described, although in more recent hydrologic studies, such as the State Water Resources Board Bulletin No. 8, "Central Basin Investigation", 1952, the basin was considered a part of the Central Basin.

Many water wells were present in the Hollywood Basin around the turn of the century, and ground water was the chief source of supply for irrigation and domestic use (Mendenhall, 1905b). Most of these wells have been since destroyed as land use changed from agricultural to urban. Most of the available water well data in the Hollywood Basin are restricted to the deep portion of the Hollywood syncline near the southern edge of the Santa Monica Mountains next to the Inglewood fault. Comparatively few wells have been drilled in other parts of the basin.

Geologic Features

The Hollywood Basin is overlain by the Hollywood Piedmont Slope and part of the La Brea Plain (Plate 2). The sediments containing known aquifers extend to a maximum depth of 650 feet (410 feet below sea level) and include Recent alluvium and the Lakewood and San Pedro formations of Pleistocene age.

The Recent alluvium covers about one-half of the basin; it ranges in thickness from about 5 to 35 feet (Plate 6G, section H-H'). Near the Santa Monica Mountains and in the western end of the basin, available well logs and excavations indicate that the alluvium consists of relatively coarse sand and gravel. Some Semiperched water may be present although aquifers have not been differentiated. Since the alluvium is thin over much of the area, it is improbable that any appreciable quantity of water could be withdrawn from it.

The Lakewood formation of late Pleistocene age extends over the whole of the Hollywood Basin and crops out at the surface in the southern half of the area. It includes the Bellflower aquiclude and the Exposition and Gage aquifers. The Bellflower aquiclude consists of silty clay and clay ranging from 5 to 35 feet in thickness (Plate 6G, Section H-H'). It extends upward from the top of the Exposition aquifer to the base of the Recent alluvium or to the surface in areas where no Recent sediments are present.

The Exposition aquifer consists of 20 to 60 feet (Plate 11A) of sand and gravel with some interbedded clay, and attains a maximum depth of 150 feet (elevation 20 feet, Plate 10A).

The Gage aquifer is the major water-bearing member of the Lakewood formation in the Hollywood Basin; it consists of 20 to 80 feet (Plate 13A) of sand and gravel with interbedded clay, and attains a maximum depth of 260 feet (100 feet below sea level) in some areas (Plate 12A). The Gage aquifer is merged with the overlying Exposition aquifer over a large area in the northern and eastern part of the basin (Plate 12A).

The San Pedro formation of early Pleistocene age contains the Jefferson, Lynwood, Silverado, and Sunnyside aquifers in the Hollywood Basin. These aquifers have been identified only in the extreme western portion of the basin, south of the City of Beverly Hills. If additional well log information were available, some, if not all, of these aquifers probably could be defined in the northern portion of the basin along the axis of the Hollywood syncline.

The Jefferson aquifer consists of 20 to 40 feet (Plate 17) of gravel with some clay and attains a maximum depth of 380 feet (150 feet below sea level, Plate 16).

The Lynwood aquifer consists of about 50 feet (Plate 19A) of gravel with a small amount of interbedded clay, and reaches a depth of about 400 feet (200 feet below sea level, Plate 18A). It is merged with the overlying Jefferson aquifer in a small area in the southwestern part of the basin east of Beverly Hills (Plate 18A).

The Silverado aquifer consists of about 50 feet (Plate 21A) of sand and gravel with a small amount of clay, and reaches a maximum depth of about 500 feet (300 feet below sea level, Plate 20A).

The Sunnyside aquifer consists of 40 to 50 feet (Plate 23) of sand and gravel with a small amount of clay, and attains a maximum depth of 660 feet (400 feet below sea level, Plate 22 and section H-H', Plate 6G).

The aquifers of the Lakewood formation are underlain by deposits of Miocene age in the eastern and southern part of the Hollywood Basin. In the extreme southwestern portion of the basin, the San Pedro formation has been identified beneath the Lakewood formation. Along the axis of the Hollywood syncline (Plate 3A), sediments of Pliocene age may underlie the San Pedro formation. These Pliocene and Miocene sediments also contain some fresh water, but no aquifers have been differentiated. They are relatively impervious and contain saline water at depth.

The major structural features of the Hollywood Basin are the Hollywood and Inglewood faults, the Hollywood syncline, and the La Brea high (Plate 3A). The Hollywood fault along the northern boundary of the basin brings Pleistocene deposits into contact with the Jurassic and younger rocks of the Santa Monica Mountains. The Inglewood fault, which forms the western boundary of the Hollywood Basin, appears to impede ground water movement between it and Santa Monica Basin. Available water level data suggest that the Hollywood Basin may be in hydraulic continuity with the Santa Monica Basin to the west along the northwestern part of the basin boundary where the presence of the Inglewood fault is largely conjectural.

The Hollywood syncline in the northern portion of the basin contains sediments of Recent, Pleistocene, and probably Pliocene age underlain by Miocene deposits. The southern flank of the syncline forms the

La Brea high, a subsurface structural high extending from the Elysian Hills almost to the Inglewood fault where it plunges steeply westward and forms an anticlinal nose in the San Pedro formation. It acts as a partial barrier to ground water movement southward into the Central Basin. The San Pedro formation was originally folded up over the La Brea high and eroded off, and the Lakewood formation has been deposited unconformably on sediments of Miocene age and on what remains of the San Pedro formation.

Occurrence of Ground Water

Ground water in the Hollywood Basin occurs mainly in sediments of Recent and Pleistocene age. Some fresh ground water is present in the Pliocene deposits which underlie the San Pedro formation near the Inglewood fault. Mendenhall (1905b) reported flowing wells in what are now known to be Miocene sediments in the eastern part of the Hollywood Basin. Recently drilled oil wells also encounter fresh water at shallow depth in these rocks in the Elysian Hills.

Unconfined ground water conditions exist in the northern and eastern portions of the basin in the shallow aquifers. In the deeper aquifers and in the remainder of the basin ground water is confined, and clay members separate the aquifers over considerable areas.

Ground water in the Hollywood Basin is replenished by percolation of precipitation and stream flow from the higher areas to the north into Recent alluvial sands and gravels. Paving of streets and lining of drainage channels have decreased greatly the surface area open to direct percolation. Subsurface inflow may take place to a limited extent from the Santa Monica Mountains where the older crystalline rocks are sufficiently fractured to allow storage and passage of water.

Ground water in the deeper aquifers of the Hollywood Basin can move to the southwest around the La Brea high, provided the ground water gradient is in that direction. Some ground water in the Lakewood formation probably moves south across the La Brea high. However, a pumping depression in the area southeast of Beverly Hills just east of the Inglewood fault causes water in the Hollywood Basin and water from the Central Basin to flow toward its center.

Aquifers in Hollywood Basin have relatively low transmissibility rates, generally being less than 40,000 gallons per day per foot of width. The Lynwood aquifer (Plate 26F) has the highest transmissibility rate (60,000 gallons per day per foot of width) in this basin. Because of the erosion of the aquifers in the San Pedro formation over the La Brea high, the overall transmissibility rate is quite low there. The area of highest combined transmissibility rate is near Beverly Hills because of the greater thickness of coarser materials (Plate 26I).

Changes in ground water storage occur in the areas of free ground water, which are primarily along the north and east portions of the basin. Total storage to the base of the Sunnyside aquifer is about 200,000 acre-feet. Historically utilized storage since 1904 amounts to about 30,000 acre-feet. The storage capacity between the historical high water level which occurred in 1904 and sea level is about 80,000 acre-feet.

Central Basin

The Central Basin extends over most of the Coastal Plain of Los Angeles County east and northeast of the Newport-Inglewood uplift (Plate 2). It is bounded on the north by the Hollywood Basin and a series of low hills extending from the Elysian Hills on the northwest to the Puente Hills on the southeast. Where the Los Angeles and Whittier Narrows break the otherwise continuous line of hills, the Central Basin is separated from the ground water basins to its north by arbitrary lines. The Central Basin is bounded on the west and south by the Newport-Inglewood uplift and on the southeast by the Los Angeles-Orange County line. All of these boundaries do not coincide with the ones defined in earlier reports. In Bulletin No. 8 (Calif. D.W.R. 1952c) the Central Basin included the area referred to in this report as the Hollywood Basin. The present Central Basin includes part of the area formerly known as the Los Angeles Narrows Basin, and the Whittier Area which was formerly the western part of the La Habra Basin.

The Central Basin was historically divided internally into three areas (Calif. D.W.R. 1934): the Los Angeles and Montebello Forebay Areas and the Central Basin Pressure Area. This division is shown on Plate 2. The forebay areas have been described as intake areas (areas of free or unconfined ground water) where substantial infiltration of surface water could occur. In the pressure area, the aquifers were pictured as being confined between relatively impervious layers of considerable lateral extent that restricted percolation of water from the ground surface downward to the underlying aquifers. This investigation has shown that such a simplified division is not possible because aquicludes were found to extend into the so-called forebay areas and the pressure area aquicludes were found locally to contain large amounts of sandy and gravelly clay and silts where considerable deep percolation could occur. The area of essentially unrestricted percolation of surface waters to the underlying ground water is limited to small areas in the vicinity of the Los Angeles and Whittier Narrows (Plate 9A). These areas are considerably smaller in extent than the historically defined Los Angeles and Montebello Forebay Areas. However, in large portions of the remainder of the basin, including the pressure area, the upper aquiclude is only partly effective in restricting downward percolation. Because of the heterogeneous pattern of these relatively permeable areas in and around the more impermeable aquicludes and the general gradation from one to the other, an attempt to divide the basin into pressure and forebay areas along a definite line for purposes of hydrologic analysis would not only be difficult but would have to be completely arbitrary. Nevertheless, the old delineation of forebay and pressure areas are used in the discussion of the geology of the Central Basin to follow because of their historical significance and descriptive usefulness.

The Central Basin is divided into four parts for descriptive purposes: the Los Angeles Forebay Area, the Montebello Forebay Area, the Whittier Area, and the Central Basin Pressure Area. The Los Angeles and Montebello Forebay Areas are located in the northern part of the Central Basin immediately south of the two breaks in the line of low hills bordering the basin. Through these breaks the Los Angeles River and the Rio Hondo-San Gabriel River systems flow from the valleys to the north into the coastal plain (Plate 2). These forebay areas spread southward from the two narrows in irregular semicircles. The southern boundary of the two forebay areas roughly coincides with the northernmost limit of the line of flowing artesian wells delineated by Mendenhall in 1903. As explained above, these forebay areas are not true forebays in the academic sense of the word but are used herein for descriptive purposes.

The Whittier Area is located in the northeastern part of the Central Basin east of the Montebello Forebay Area, south of the Puente Hills and west of the Orange County line. The Whittier Area was described as part of the La Habra Basin in Bulletin 45 (Calif. D. W. R. 1934). However, since the aquifers present in this area, especially the deeper ones, are interconnected to varying degrees with the aquifers in the Central Basin, the area was renamed and treated as part of the Central Basin.

The Central Basin Pressure Area is the largest of the four divisions of the Central Basin. It encompasses all of the area east and northeast of the Newport-Inglewood uplift and northwest of the Orange County line that is not included in the other three areas. It is called a "pressure area" because the aquifers within it are confined by aquicludes or relatively impermeable layers of clay and silt over most of the area. One of the most important aquicludes is at or near the surface. As noted previously, this near surface aquiclude is missing in local areas and contains zones of relatively more permeable material in many places where water could move into or out of the underlying aquifer. Accordingly, completely confined conditions do not exist in the pressure area.

It should also be noted in this discussion of basin divisions that the pressure area could be further divided on the basis of a ground water mound which has existed in the northwestern portion of the basin since the early 1930's. This mound effectively divides the ground water movement in that portion of the basin into two parts; that which moves northward toward the Hollywood Basin and that which moves southeasterly toward the center of the old pressure area and the Los Angeles Forebay Area. This ground water mound was used in the formulation of a portion of the northern boundary of the Central and West Basin Water Replenishment District organized in 1959 (Calif. D.W.R. 1959).

In the sections which follow, the geologic features of the Los Angeles Forebay Area, the Montebello Forebay Area, the Whittier Area and finally the Central Basin Pressure Area are summarized. For each area these summaries include information about the aquifers present, the areas where these aquifers merge, and barriers to ground water movement. The flow of water into and out of the Central Basin as a whole, replenishment of the aquifers, and areas of free ground water and storage change are described in a separate section under the heading of "Occurrence of Ground Water in the Central Basin".

Geologic Features of the Los Angeles Forebay Area

The Los Angeles Forebay Area, located in the northern part of the Central Basin, is shown on Plate 2. In general it is a free ground water area; however, in the course of this investigation it became evident that the Bellflower aquiclude extends into the southerly portion of the forebay area. The aquiclude in this area contains a high percentage of sand, and vertical percolation of water is apparently more rapid here than in other portions of the basin covered by it. Where the Bellflower aquiclude is missing within the forebay area (see Plate 8A), the aquifers are in direct hydraulic continuity with the surface.

The Los Angeles Forebay Area is overlain by parts of the La Brea, Downey, and Montebello Plains. The known water-bearing sediments extend to a depth of 1600 feet (1440 feet below sea level) and include Recent alluvium, the Lakewood formation, and the San Pedro formation. Some fresh water also may be present in the Pliocene and Miocene rocks underlying these formations in this area.

Recent alluvium in the Los Angeles Forebay Area is found on the Downey Plain and in the Los Angeles Narrows. It attains a maximum thickness of 160 feet, and includes the western arm of the Gaspur aquifer and the parts of the Semiperched aquifer and Bellflower aquiclude lying west and south of the Los Angeles River.

The Semiperched aquifer is defined as the area where sand and gravel overlying the Bellflower aquiclude is more than 20 feet in thickness. This Semiperched aquifer is also present in the Lakewood formation just south of the Repetto Hills. Although the aquifer can be defined on well logs, water levels in wells indicate that it contains little or no water.

The Bellflower aquiclude consists of clay and sandy clay, ranging from 0 to 90 feet in thickness (Plate 9A) and attains a maximum depth of 100 feet (elevation 40 feet) in the southern part of the forebay area (Plate 8A). It is also present in the Lakewood formation in which it underlies the Semiperched aquifer east and north of the Los Angeles River and extends south into the Central Basin Pressure Area. In the Lakewood formation it varies from less than 40 feet to 50 feet or more in thickness, consists of clay and sandy clay, and attains a maximum depth of 80 feet (elevation 20 feet, Plate 9A). The lack of water in the Semiperched aquifer overlying the Bellflower aquiclude suggests that the Bellflower aquiclude is reasonably permeable in the forebay area.

The Gaspur aquifer consists mainly of sand and gravel with a very small percentage of clay. It ranges from 10 to more than 80 feet in thickness (Plate 11A) and extends down to a depth of 160 feet (60 feet below sea level, Plate 10A). The Gaspur aquifer is overlain by the Bellflower aquiclude over part of the forebay area. However, in the smaller area open to direct percolation shown on Plate 10A, the Gaspur aquifer is either exposed at the surface or overlain by a thin layer of fine sand or soil.

The Lakewood formation is exposed on the surface of the La Brea and Montebello Plains and extends underneath the Recent alluvium on the Downey Plain. It is present in the Los Angeles Narrows, but aquifers have not been defined there. The Lakewood formation includes the portions of the Bellflower aquiclude and the overlying Semiperched aquifer east and north of the Los Angeles River and the Exposition, Gardena, and Gage aquifers. It ranges from 0 to more than 220 feet thick in the southern part of the area.

The Exposition aquifer has been delineated in that portion of the Los Angeles Forebay Area that is beyond the boundaries or limits of the Gaspur aquifer. The Expositon aquifer consists of as many as three sand and gravel members separated in some areas by discontinuous clay and silt lenses. It attains a maximum thickness of 80 feet (Plate 11) and varies in depth from 100 to 160 feet (elevation 200 to 20, Plate 10). Although the Exposition aquifer is known to extend beneath the Gaspur aquifer, it was not differentiated from the Gaspur aquifer, because the contact between the two is indistinct.

The Gardena aquifer is present over much of the Los Angeles Forebay Area. It consists mainly of sand and gravel with a little clay, and ranges from 0 feet to 60 feet thick (Plate 13A). The maximum depth is 290 feet (100 feet below sea level, Plate 12A).

The Gage aquifer is also present in the forebay area, but over a large part of the area it has been eroded away and subsequently replaced by the Gardena aquifer. The Gage aquifer consists of sand and sandy clay with some gravel. It ranges from 5 feet to 100 feet in thickness (Plate 13A) and extends to a depth of 375 feet (250 feet below sea level, Plate 12A). The Gage aquifer is the basal member of the Lakewood formation. It rests unconformably on the underlying San Pedro formation, except in the extreme northern part of the area, where the San Pedro is missing (Plate 6E, section K-K'-K").

The San Pedro formation is the lowest, stratigraphically, of the formations in the Los Angeles Forebay Area that contain known aquifers. It crops out along the southern edge of the Repetto Hills and extends over the whole of the forebay area except in the Los Angeles Narrows. The San Pedro formation is about 1,050 feet thick in the Los Angeles Forebay Area and includes the Hollydale, Jefferson, Lynwood, Silverado and Sunnyside aquifers.

The Hollydale aquifer is missing in the west end of the forebay. In the rest of the area, it consists of sand and sandy clay with some gravel. It ranges from 0 feet to 60 feet in thickness (Plate 15) and extends 475 feet (350 feet below sea level, Plate 14).

The Jefferson aquifer is missing in the extreme southern part of the forebay area. In the Central and northern portions of the area, it consists of sand with some gravel and clay. It ranges from 0 to 70 feet in thickness (Plate 17) and extends 640 feet down (450 feet below sea level, Plate 16).

The Lynwood aquifer is present over all of the Los Angeles Forebay Area where the San Pedro formation occurs. It consists maily of sand and gravel with a little clay, ranges from 20 feet to 130 feet in thickness, (Plate 19A) and extends down to 720 feet (600 feet below sea level, Plate 18A).

The Silverado aquifer is found throughout most of the Los Angeles Forebay Area and consists of gravelly sand with some interbedded clay. It ranges from 20 feet to 150 feet in thickness (Plate 21A) and extends 1,070 feet down (880 feet below sea level, Plate 20A).

The Sunnyside aquifer also is found over most of the forebay area and consists mainly of sand with interbedded clays. It ranges from 50 to 430 feet in thickness (Plate 23) and extends down to 1,600 feet (1,440 feet below sea level, Plate 22).

The San Pedro formation is unconformably underlain by sediments of Pliocene age which probably contain fresh water in their upper portions.

Within the Los Angeles Forebay Area, the Miocene and Pliocene rocks and the San Pedro formation in the north limb of the Paramount syncline dip to the south. There is a sharp angular unconformity between the steeply dipping, truncated San Pedro formation, and the overlying gently dipping Lakewood formation. This unconformity permits water moving through the Recent and Lakewood formations to percolate downward into the aquifers of the San Pedro formation. (See sections J-J'-J", Plate 6D and K-K'-K", Plate 6E). To the north, in the narrows itself, the Recent alluvium rests directly upon Miocene rocks. Erosion has removed all of the San Pedro formation here, as well as parts of the Lakewood formation which occurs only as terrace remnants along the sides of the narrows.

Movement and occurrence of ground water in the Los Angeles Forebay Area and the other areas in the Central Basin will be discussed later.

Geologic Features of the Montebello Forebay Area

The Montebello Forebay Area extends southward from the Whittier Narrows and presently is the most important area of recharge in the Central Basin. The boundary, shown on Plate 2, is the same as the Montebello Forebay Area boundary described in Bulletin No. 45 (Calif. D.W.R. 1934).

The Montebello Forebay Area is overlain by parts of the Montebello, Downey, and Santa Fe Springs Plains. The water-bearing sediments vary in age from Recent to early Pleistocene and extend to a maximum depth of about 1,050 feet (900 feet below sea level).

The Recent alluvium contains parts of the Semiperched aquifer and the Bellflower aquiclude, and the eastern arm of the Gaspur aquifer. The Semiperched aquifer consists of 20 to 60 feet of sand and gravel overlying the Bellflower aquiclude. The Semiperched aquifer is of Recent age over most of the area but in the northwest corner of the area it is part of the Lakewood formation of late Pleistocene age. The Bellflower aquiclude (Plates 8A and 9A) also is found both in Recent alluvium and the Lakewood formation in the Montebello Forebay Area. It consists of clay and sandy clay ranging in thickness from a few feet at its edge to about 60 feet northeast of Downey. Well logs and other data collected for this report show that where the Bellflower aquiclude extends into the forebay area, it contains a high percentage of sand and gravel. These data suggest that the permeability is sufficiently high to allow percolation through the aquiclude in portions of this area, and therefore it is not an aquiclude in fact in those areas. The areas where the Bellflower aquiclude is not present are shown on Plates 8A and 9A.

The eastern arm of the Gaspur aquifer extends northeasterly through the Montebello Forebay Area and into the Whittier Narrows. It consists of coarse sand and gravel ranging from 40 to 100 feet in thickness (Plate 11A). The maximum thickness is found in the vicinity of the Whittier Narrows Dam, and the maximum depth of 125 feet (20 feet below sea level) occurs in the vicinity of Downey (Plate 10A). The Gaspur aquifer is exposed at the ground surface from Whittier Narrows south to Imperial Highway (Plate 10A). South of this point it is overlain by the Bellflower aquiclude.

The Lakewood formation in the Montebello Forebay Area contains parts of the Semiperched aquifer and the Bellflower aquiclude mentioned earlier, and the Artesia, Exposition, Gage, and Gardena aquifers.

The Artesia and Exposition aquifers, present over a limited area in the Montebello Forebay (Plates 10A and 11A), appear to be contemporaneous in age and mode of deposition. The name "Artesia aquifer" has been given to water-bearing sediments immediately underlying the Bellflower aquiclude east and south of the Gaspur aquifer. The Exposition aquifer consists of similar deposits extending west and north of the eastern arm of the Gaspur aquifer. The Artesia and Exposition aquifers consist of from 10 to 90 feet of sand and gravel with some clay. The sediments comprising these aquifers underlying the Gaspur aquifer had been mostly eroded away prior to deposition of the Gaspur aquifer, and no effort has been made to identify those portions of the aquifers that may remain beneath the Gaspur. The composite name, Artesia-Exposition aquifer, is used for these water-bearing deposits which underlie and are in hydraulic continuity with the Gaspur aquifer.

The Gage aquifer (Plates 12A and 13A) is composed mainly of sand ranging from 20 to 80 feet in thickness, and extends over approximately one-third of the forebay. The maximum thickness is found in the vicinity of Montebello. The maximum depth of 260 feet (150 feet below sea level) is southeast of Downey.

The Gardena aquifer (Plates 12A and 13A) is present over about two-thirds of the Montebello Forebay. This aquifer, deposited in channels incised into the Gage aquifer, is coarse sand and gravel and ranges from 20 to 140 feet in thickness. The maximum thickness is found just north of the Whittier Narrows Dam. The sediments extend down to a maximum depth of 265 feet (150 feet below sea level) north of Norwalk.

The San Pedro formation has been identified throughout the Montebello Forebay Area beneath the Lakewood formation. It also crops out on the south side of the Repetto Hills west of the Rio Hondo. All of the aquifers of the San Pedro formation are present in the Montebello Forebay Area. The Hollydale aquifer (Plates 14 and 15) is present over about one-half of the area and is compsed of about 20 to 60 feet of sand and gravel with a small amount of interbedded sandy clay and clay. The maximum depth of 260 feet (250 feet below sea level) occurs about one mile north of Norwalk. The Jefferson aquifer (Plates 16 and 17) has been identified over about three-quarters of the Montebello Forebay Area. It ranges in thickness from 20 to 60 feet and consists of sand and sandy clay. The maximum depth of 505 feet (300 feet below sea level) occurs about a mile north of Norwalk.

The Lynwood aquifer (Plates 18A and 19A) is found throughout the Montebello Forebay Area. It is mainly coarse sand and gravel ranging from 50 to 150 feet in thickness. The maximum depth of 705 feet (450 feet below sea level) occurs about one mile north of Norwalk. This aquifer yields water to many wells in the Montebello Forebay Area. The Silverado aquifer (Plates

20A and 21A), identified throughout the Montebello Forebay Area, ranges from 50 to 200 feet in thickness, and is about half sandy gravel and half interbedded clay. The maximum depth of about 1,000 feet (900 feet below sea level) is also just north of Norwalk.

The Sunnyside aquifer (Plates 22 and 23) is the basal member of the San Pedro formation and is the deepest aquifer identified in the Montebello Forebay Area. It is generally sand with local areas of coarse gravel and ranges in thickness from 100 to 350 feet. The maximum depth of about 1,400 feet (1,300 feet below sea level) occurs north of Norwalk.

The San Pedro formation is underlain by Pliocene deposits which are water bearing in some areas. Electric logs of oil wells show that fresh water is present below the San Pedro formation in the Montebello Forebay Area but no aquifers have been delineated in these older sediments.

The major structural features of the Montebello Forebay Area are the unconformity between the Lakewood and San Pedro formation and the faulting and folding in the Whittier Narrows. Geologic sections A-A'-A", Plate 6A, M-M', and N-N', Plate 6F and P-P', Plate 6G, show the gently dipping formations in the Whittier Narrows, and Plate 7 shows cutaway views of the aquifers therein. The Rio Hondo, Pico, and Cemetery faults, all trending approximately northeast, have been postulated in the Whittier Narrows where they evidently bound two distinct, folded blocks (see section on Whittier Narrows Area in Chapter V).

The Rio Hondo fault follows approximately along the southwest side of the Rio Hondo. It displaces the Gardena, Lynwood, and Sunnyside aquifers. The Recent alluvium continues unaffected across the fault. On the northwest side of the Rio Hondo fault, the Sunnyside aquifer has been downdropped as much as 600 feet with respect to the aquifer on the southeast side. Northwest of the Rio Hondo fault near Whittier Narrows Dam, erosion has removed all aquifers between the Sunnyside and Gardena aquifers (geologic section P-P', Plate 6G).

The Pico fault extends parallel to the Rio Hondo fault and lies about one mile southeast of it. Only the aquifers of the San Pedro formation are cut by this fault, with the southeast side having been downdropped. The amount of offset varies along the fault and, for the Sunnyside aquifer, the maximum vertical offset is about 400 feet. This places the Sunnyside aquifer on the northwest side of the fault opposite the Lynwood and Jefferson aquifers on the southeast side, thus retaining some hydraulic continuity across the fault.

The Cemetery fault is located along the east side of Whittier Narrows and trends slightly east of north. No cross sections in this report cross through this fault. Because the fault coincides with the contact between the Recent alluvium of the Narrows and Pliocene formations of the Puente Hills and since data are not available to differentiate aquifers east of the fault in the Pliocene sediments, any displacement and the effect of the fault upon ground water movement cannot be ascertained.

Some idea of the complexity of the folding in the Whittier Narrows can be seen on geologic sections A-A'-A", M-M', N-N' and P-P' of Plates 6A, 6F, and 6G. Cutaway diagrams of aquifers in the vicinity of Whittier Narrows are shown on Plate 7, with the Gaspur, Gardena, and Silverado aquifers stripped off in succession. The fault displacement and folding can be understood particularly well with the use of this plate.

Ground water movement within the Whittier Narrows in a northwest-southeast direction would probably be impeded by these faults. Fortunately, the faults trend is essentially parallel to the main subsurface inflow to the Central Basin through the Whittier Narrows and apparently do not affect this ground water movement.

Geologic Features of the Whittier Area

The Whittier Area of the Central Basin extends from the Puente Hills south and southwest to the axis of the Santa Fe Springs-Coyote Hills uplift. The western boundary is an arbitrary line separating the Whittier Area from the Montebello Forebay Area; the eastern boundary is the Orange County line (see Plate 2). The name "Whittier Area" is used for the first time in this report. In prior publications this area was considered to be part of the La Habra Basin (Calif. D.W.R. 1934 and 1947), the southern boundary of which coincided with the southern edge of the Coyote Hills. The southern boundary of the Whittier Area used in this report was chosen because it is a drainage divide and water applied on the south flank of the Coyote Hills would drain into the Central Basin Pressure Area.

Water well data are almost entirely lacking for the sediments found in the east end of the Whittier Area and around the City of Whittier. However, it is reasonably certain that ground water is present in these areas. In the portion of the Whittier Area where aquifers have been defined, many of the old wells have been destroyed and water level data are no longer available. Consequently, the descriptions of the aquifers and aquicludes present in the Whittier Area are not complete.

The Whittier Area is overlain by the La Habra Piedmont Slope and part of the Santa Fe Springs Plain and the Coyote Hills (Plate 2). The known water-bearing sediments, extending to a depth of about 1,000 feet (800 feet below sea level), include Recent alluvium and the Lakewood and San

Pedro formations. A part of the underlying Pliocene and older deposits may also contain water of good quality. Electric logs of oil wells in the Whittier Area indicate fresh water at greater depths than have been penetrated by water wells.

Recent alluvium in the Whittier Area consists of a thin finger of sand, gravel, and clay, which extends into the western portion of the area from the Montebello Forebay Area (Plate 3A). The sediments are 80 feet thick near the western boundary of the area, and thin out to the east. The Recent alluvium contains a portion of the Bellflower aquiclude and the Gaspur aquifer.

The Bellflower aquiclude in the Recent alluvium consists of clay and sandy clay ranging from 10 to over 40 feet in thickness (Plate 9A). It overlies the Gaspur aquifer in the extreme western part of the area. In much of the Whittier Area, the Bellflower aquiclude is part of the undifferentiated Lakewood formation. Lack of data in many parts of the area where the Lakewood formation is exposed at the surface makes it difficult to define the thickness, extent, and composition of this aquiclude. Where data are available, the Bellflower aquiclude is clay and sandy clay averaging 20 feet in thickness and extending down to a depth of about 70 feet below the ground surface (elevation 120 feet, Plate 8A). The degree to which the ground water can be transmitted through the Bellflower aquiclude depends on the thickness and composition of the aquiclude. While the aquiclude appears to be continuous over most of the Whittier Area, it may be either absent in some areas or so thin and discontinuous that ground water can be transmitted through it at an appreciable rate.

The Gaspur aquifer is mainly sand and gravel with a small amount of interbedded clay. It ranges from 30 to 60 feet in thickness (Plate 11A) and attains a depth of 145 feet below the surface (elevation 60 feet, Plate 10A).

The Lakewood formation crops out over most of the Whittier Area (Plate 3A). It consists of continental deposits of late Pleistocene age and attains a maximum thickness of 70 feet. The Lakewood formation contains the Artesia and Gage aquifers and that part of the Bellflower aquiclude described above.

The Artesia aquifer extends a short distance into the southwest corner of the Whittier Area in the vicinity of Santa Fe Springs. It is mostly sand with some interbedded clay and has an average thickness of about 40 feet (Plate 11A) and a maximum depth of about 50 feet (elevation 60 feet, Plate 10A). This aquifer is near the surface and has been exposed in excavations on the Santa Fe Springs Plain.

The Gage aquifer is the major water-bearing member of the Lakewood formation in the Whittier Area. It has been delineated only in the southern portion of the area and near the Los Angeles-Orange County line, where it consists of about 30 feet (Plate 13A) of sand with some interbedded clay, and has a maximum depth of about 150 feet (elevation 50 feet, Plates 12A and 6A, section B-B'-B").

The San Pedro formation underlies the entire Whittier Area, where it attains a maximum thickness of about 850 feet and extends down to a depth of about 920 feet (850 feet below sea level). The formation is composed of sand and gravel with interbedded clay, all probably of marine origin. Clay members separate the sands and gravels comprising the aquifers over most of the basin. The San Pedro formation contains the Hollydale, Jefferson, Lynwood, Silverado, and Sunnyside aquifers. An extensive unconformity brings the aquifers of the San Pedro formation into contact with those of the Lakewood formation along the northern boundary of the area and along the edge of the Coyote Hills. Cross sections B-B'-B" and Q-Q' on Plates 6A and 6G show this relationship.

The Hollydale aquifer has been identified only in the western part of the Whittier Area. It may be present over the rest of the area, but data are lacking. It ranges in thickness from 10 to 25 feet (Plate 15) and consists of sand and gravel with a small amount of interbedded clay. It appears to reach a maximum depth of about 100 feet (elevation 50 feet, Plate 14). It is merged with the overlying Gage aquifer in the vicinity of South Whittier.

The Jefferson aquifer ranges in thickness from 20 feet to 40 feet (Plate 17) and consists of sand and gravel with a little interbedded clay. It extends over most of the Whittier Area and reaches a maximum depth of about 350 feet (100 feet below sea level, Plate 16). In the western part of the area, near the boundary with the Montebello Forebay, the Jefferson aquifer merges with the overlying Hollydale aquifer.

The Lynwood aquifer is present throughout the Whittier Area. It ranges in thickness from 50 to 100 feet (Plate 19A) and consists of sand and gravel with some interbedded clay. It extends to a maximum depth of about 460 feet (300 feet below sea level, Plate 18A).

The Silverado aquifer has been identified over all of the Whittier Area. It consists of 110 to 300 feet of sand and gravel with finer grained phases in some areas (Plate 21A). It extends to a depth of about 750 feet (600 feet below sea level, Plate 20A).

The Sunnyside aquifer also has been identified throughout the Whittier Area. It consists of 200 to 300 feet of sand and gravel with some interbedded clay (Plate 23). It is the lowest of the aquifers identified, reaching a maximum depth of about 1,000 feet (700 feet below sea level, Plate 22). The gravels exposed in the Coyote Hills and along the north side of the area are believed to be surface outcrops of the Sunnyside aquifer.

The Pliocene and Miocene sediments below the San Pedro formation generally contain saline water in this area, but may locally contain fresh water. Plate 24A shows the approximate elevation of the base of fresh water-bearing sediments.

The available data suggest that some of the water-bearing sediments in the Whittier Area may have been faulted. However, the location of such faulting and its effect on ground water has not been determined.

The water-bearing sediments of the Whittier Area comprise part of the generally east-west trending La Habra syncline. The Recent deposits are essentially undisturbed. The Lakewood formation underlying the Recent alluvium is also generally flat-lying, though in some areas it is slightly tilted. The San Pedro formation, however, which unconformably underlies the Lakewood formation, has been folded sharply and its flanks are exposed in the Coyote Hills and on the south side of the Puente Hills. The effects of this unconformity and the outcrops of the moderately dipping San Pedro formation upon the occurrence and movement of ground water will be discussed later.

Geologic Features of the Central Basin Pressure Area

The Central Basin Pressure Area, previously known as the Central Coastal Plain Pressure Area, is overlain by the Downey Plain and parts of the Santa Fe Springs, Montebello, La Brea, and Bouton Plains. The area is generally flat and slopes gently to the south. Water-bearing sediments in the Central Basin Pressure Area range in age from Recent to Pliocene and extend to a probable maximum depth of 2,200 feet northeast of the City of Lakewood. Aquifers have been defined in the Recent alluvium and the Lakewood and San Pedro formations.

In this pressure area the aquifers are confined by many aquicludes, only one of which has been named. This is the near surface Bellflower aquiclude which restricts vertical percolation into the Gaspur and other underlying aquifers. Water levels in the confined area form a piezometric or pressure surface rather than a free ground water surface. As pressures change from aquifer to aquifer, the corresponding piezometric water levels in wells tend to vary according to which aquifer or aquifers are used for production. Also, as the aquicludes vary in extent, configuration, permeability, and thickness, their effectiveness as confining members also changes from place to place and with this change an exchange of water between aquifers may take place, depending on the direction of the pressure gradient.

The Recent alluvium covers most of the Central Basin Pressure Area, and attains a probable maximum depth of 200 feet near the City of Bellflower. It contains the Semiperched aquifer, the Bellflower aquiclude, and the Gaspur aquifer. The Semiperched aquifer consists of sands and gravels 20 to 60 feet thick overlying the Bellflower aquiclude.

The Bellflower aquiclude is found throughout the pressure area and is composed mainly of clay and silt; however, there are numerous areas where it consists mainly of clayey sands and gravels and where its effectiveness as an aquiclude is limited. It ranges from a few feet to 160 feet in thickness (Plate 9A). It extends downward to about 200 feet (140 feet below sea level) southwest of the City of Bellflower (Plate 8A). The Bellflower aquiclude is also present in the Lakewood formation but no effort has been made to define separately the areas where the aquiclude is identified with each age. The Gaspur aquifer extends south from the forebay areas in two separate arms which merge in the vicinity of the City of Lynwood and then extend south along the course of the Los Angeles River to the ocean. The Gaspur aquifer consists of coarse sand and gravel and ranges in thickness from 40 to 100 feet (Plate 11A). The maximum depth of about 190 feet (170 feet below sea level) occurs in the vicinity of Terminal Island in San Pedro Bay (Plate 10B).

The Lakewood formation, of late Pleistocene age, extends over all of the Central Basin Pressure Area. It contains part of the Bellflower aquiclude and the Artesia, Exposition, Gage, and Gardena aquifers. The water-bearing materials immediately underlying the Bellflower aquiclude west of the easterly arm of the Gaspur aquifer are called the Exposition aquifer. The water-bearing materials immediately underlying the Bellflower aquiclude east of this arm of the Gaspur aquifer are called the Artesia aquifer and are believed to be contemporary both in age and mode of deposition with the materials in the Exposition aquifer. The boundary between the Artesia and Exposition aquifers is somewhere in the center of the basin under the Gaspur aquifer. All three aquifers are in hydraulic continuity. Both the Artesia and Exposition aquifers consist of sand and gravel with local areas of interbedded clay. The Exposition aquifer ranges from 20 to over 100 feet in thickness (Plate 11A) and reaches a maximum depth of about 230 feet (120 feet below sea level) southeast of Huntington Park (Plate 10A).

The Artesia aquifer consists of 10 to 140 feet of sand and gravel with some interbedded clays (Plate 11A). It extends down to a maximum depth of 230 feet (220 feet below sea level) southeast of the City of Lakewood (Plate 10A).

The Gage and Gardena aquifers of the Lakewood formation are also considered to be the same age. Their relationship was discussed in this chapter in the section on the West Coast Basin. The Gage aquifer consists of fine-grained sand and silty sand ranging from 5 to 120 feet in thickness (Plate 13A). The maximum depth attained is 380 feet (350 feet below sea level) west of the City of Lakewood (Plate 12A). The Gardena aquifer consists of coarse-grained sand and gravel from 10 to 60 feet in thickness. It extends down to a depth of about 390 feet (350 feet below sea level) near the City of Lynwood. The Gage and Gardena aquifers mark the base of the Lakewood formation and along this base they abut the underlying San Pedro formation unconformably.

The San Pedro formation, present throughout the Central Basin Pressure Area, contains some of the most important aquifers in the area. In all, five aquifers, the Hollydale, Jefferson, Lynwood, Silverado, and Sunnyside, have been delineated.

Two relatively minor aquifers, the Hollydale and Jefferson aquifers, are present in the upper part of the San Pedro formation in the Central Basin Pressure Area. The Hollydale aquifer, uppermost of the two, (Plates 14 and 15) extends over approximately 60 percent of the area. It is mostly sand and silty sand with interbedded clays, though some gravel is found locally. It ranges from approximately 10 to 100 feet in thickness, and the maximum depth of about 570 feet (500 feet below sea level) is reached a few miles east of the City of Compton. The Jefferson aquifer (Plates 16 and 17) is present over only 40 to 50 percent of the pressure area. It is mostly fine-grained sand with scattered lenses of gravel, and ranges in thickness from about 10 feet to over 140 feet. The maximum depth of approximately 720 feet (650 feet below sea level) is found near the Orange County line southeast of the City of Norwalk. Although these two aquifers are not continuous over the entire Central Basin Pressure Area, they are important sources of water in some localities.

Both the Lynwood and Silverado aquifers yield considerable water to wells in the Central Basin Pressure Area. The Lynwood aquifer (Plates 18A and 19A) is composed mainly of coarse-grained sands and gravels, ranging in thickness from less than 50 feet to over 150 feet. The maximum depth of about 1,030 feet (950 feet below sea level) occurs southeast of the City of Norwalk. The Silverado aquifer (Plates 20A and 21A) is composed largely of sands and gravels, ranging in thickness from about fifty feet to over 450 feet. The greatest depth is found north of the City of Lakewood, where its base is about 1,240 feet below the ground surface (1,200 feet below sea level). The base of the Silverado aquifer was thought to correspond to the base of the Pleistocene deposits and of fresh water in the West Coast Basin, where it was first named. In the Central Basin, however, the Sunnyside aquifer has been differentiated below the Silverado aquifer.

The Sunnyside aquifer (Plates 22 and 23) marks the base of the San Pedro formation in most parts of the Central Basin Pressure Area. It varies from about 70 feet to over 500 feet in thickness and consists of sand, and sand and gravel. The maximum depth of about 1,700 feet (1,660 feet below sea level) occurs east of the City of Lakewood.

Below the Sunnyside aquifer is a thick section of Pliocene deposits, the coarse zones of which contain fresh water, as indicated by electric logs of oil wells. Around the margins of the Central Basin Pressure Area, where many oil fields exist and more data are available, it is apparent that the fresh water was introduced into the Pliocene sediments by flushing the saline water toward the ocean. Much of the pressure area is in the South Gate-Santa Ana depression where only widely scattered exploratory type oil well data are available. No contours depicting the base of fresh water could be drawn through this area; however, the replacement of saline waters with fresh water appears to have occurred here as well.

The structural features which control or influence the occurrence and movement of ground water in the Central Basin Pressure Area are the South Gate-Santa Ana depression and the Newport-Inglewood uplift. The South Gate-Santa Ana depression extends from south of Beverly Hills into Orange County. It is bounded by transitional structures adjacent to the Puente and Repetto Hills on the northeast and the Newport-Inglewood uplift on the southwest. The Recent sediments in this depression are generally flat-lying as are the underlying deposits of the Lakewood formation. The San Pedro formation, however, is moderately folded and unconformably underlies the younger formations in most of the Central Basin.

The major structural features in the South Gate-Santa Ana depression are the Paramount syncline and Los Alamitos fault, and the Norwalk syncline. These structures appear to be developed only in the San Pedro formation, and they do not affect the overlying younger sediments. The Paramount syncline underlies the City of Paramount and extends northwesterly to the Inglewood fault north of the Baldwin Hills. The Los Alamitos fault appears as an extension of the axis of the Paramount syncline southeast of the City of Paramount. The Norwalk syncline extends from the City of Norwalk southeasterly to the Orange County line. It is separated from the Los Alamitos fault by an unnamed anticlinal fold which extends into Orange County. None of these structural features appear to materially affect ground water movement in the Central Basin Pressure Area.

The faults and anticlinal folds of the Newport-Inglewood uplift mark the west and southwest boundary of the Central Basin Pressure Area and are partial barriers to movement of ground water from the Central Basin to the West Coast Basin, as has been previously discussed.

Occurrence of Ground Water in the Central Basin

In all four areas of the Central Basin ground water is found in the Recent alluvium, the Lakewood and San Pedro formations, and sometimes in the older sediments. The aquifers in these formations have been discussed above under separate headings for each area of the Central Basin. The paragraphs that follow will take up the movement of ground water into and through the Central Basin as a whole, rather than by separate areas.

Ground water enters the Central Basin through surface and subsurface flow and by direct percolation of precipitation, stream flow, and applied water. The main surface and subsurface flow into the basin is through the Los Angeles and Whittier Narrows from the ground water basins in the interior valleys. However, minor subsurface flow probably enters the area from the bordering relatively impermeable formations, and some subsurface flow can take place from the other surrounding ground water basins.

Replenishment of the aquifers by percolation of precipitation, stream flow, and applied water occurs in the forebay areas where permeable sediments are exposed at ground surface. In addition, some water also moves into the aquifers where they crop out on the surface against the surrounding highlands and in those portions of the pressure area where the Bellflower aquiclude is missing or contains considerable sand and gravel.

In the Los Angeles and Montebello Forebay Areas the aquifers are in hydraulic continuity in varying degrees, with each other and with the ground surface. In some instances this hydraulic continuity results from the aquifers being superposed one on another with no intervening clay members. Areas where each aquifer is merged with the overlying one are shown on the plates depicting lines of equal elevation on the base of each aquifer

(Plates 10A, 12A, 14, 16, 18A, 20A, and 22). In other portions of the forebay areas aquicludes present between the aquifers restrict direct movement of ground water between aquifers. However, these aquicludes are not continuous over the entire area; consequently, the hydraulic gradient controls the lateral movement of ground water to points where the aquifers are merged.

The areas of contact between aquifers and areas of contact with the ground surface are important because it is only through these areas that surface water can be introduced by spreading into the aquifers in major quantity. The most important area in this regard in the Coastal Plain of Los Angeles County is in the vicinity of the Whittier Narrows in the Montebello Forebay Area because of the interconnection of the deeper aquifers through the shallower ones to the ground surface. This condition also exists in the vicinity of the Los Angeles Narrows in the Los Angeles Forebay Area, but the paving of this area has essentially eliminated surface recharge to the aquifers below.

Plate 25, entitled "Areas Where Aquifers are Merged with Permeable Surface Deposits or Overlying Aquifers in Vicinity of Whittier Narrows" shows the generalized interconnections in and near the Whittier Narrows in the Montebello Forebay Area and the areas of essentially direct connection between the aquifers and the ground surface. This plate was derived from the detailed delineation of the areas of mergence shown on the plates depicting lines of equal elevation on the base of each aquifer.

Water applied on the surface can move directly into the Gaspur aquifer within the area shown on Plate 25. The Gage and Gardena aquifers immediately underlie the Gaspur aquifer and they are in hydraulic continuity. Below the Gage and Gardena aquifers are the Hollydale and Jefferson aquifers which are generally merged with the Gage and Gardena aquifers. This relationship is shown on Plates 12A, 14, 16, and Plate 25. These interconnections provide essentially complete continuity with the surface through the Gaspur aquifer. The areas of mergence of the deeper aquifers with the overlying ones are much more restricted and these limited areas are shown on Plate 25 as well as on Plates 18A, 20A, and 22. It will be noted from Plate 25 that the area of direct vertical recharge from the ground surface to the Lynwood aquifer is about one-third of the area of the Gaspur in contact with the ground surface. The area of direct vertical recharge to the Silverado and Sunnyside aquifers is even more restricted and is limited to a very small area in the immediate vicinity of Whittier Narrows Dam. These limited areas of interconnection severely restrict the amount of recharge that can directly reach the deeper aquifers from the ground surface. Fortunately, the areas of mergence through which water can reach the lower aquifers by devious paths is considerably larger than shown on Plate 25 (see Plates 12A, 14, 16, 18A, 20A, and 22). Therefore, even though the direct downward infiltration may be restricted or entirely impeded by an intervening aquiclude, water can move laterally in one aquifer to a point where the aquifer is merged with a lower one, permitting water applied at the surface to reach and replenish the deeper aquifers.

The areas of mergence between aquifers in the Los Angeles Forebay also are shown on the plates depicting lines of equal elevation on the base of each aquifer. It is evident that considerable opportunity existed for infiltration of water from the ground surface into the Gaspur aquifer and on into the deeper aquifers of the basin. However, as noted before, this area now is essentially covered with impervious material and the opportunity for surface recharge of the aquifers is practically nonexistent.

This is unfortunate from the standpoint of ground water basin utilization since the available storage capacity in the Los Angeles Forebay is large.

Under present conditions, ground water in the Montebello Forebay Area moves into the Los Angeles Forebay Area, the Whittier Area, and the Central Basin Pressure Area. Ground water from the Los Angeles Forebay Area also moves into the Central Basin Pressure Area. In the northern portion of the pressure area a ground water mound exists which separates ground water movement into two parts. North of this mound ground water moves northward into the Hollywood Basin while south of this mound ground water moves southwesterly toward the West Coast Basin.

Ground water movement in the Whittier Area in July 1958 was to the west and southwest in both the deep and shallow aquifers. The Santa Fe Springs-Coyote Hills uplift, the axis of which serves as the southern boundary of the Whittier Area, appears to restrict ground water movement to the south into the Central Basin Pressure Area in the aquifers of the Lakewood formation. The aquifers of the San Pedro formation are continuous across the uplift and it is reasonable to assume that ground water movement to the south could take place if the hydraulic gradient sloped in that direction.

Historically, subsurface flow took place from the Central Basin across the Newport-Inglewood uplift into the West Coast Basin. However, pumping has lowered the water level in the Central Basin and at present water levels in some aquifers are about equal on both sides of the Newport-Inglewood uplift. Further lowering of water levels on either side of the uplift could result in a hydraulic gradient being established which would slope toward the point of the lower water level with a consequent flow of water in that direction. A relatively small amount of subsurface flow occurs out of the Central Basin Pressure Area because most of the ground water moves to a series of pumping holes developed along the Newport-Inglewood uplift north of Dominguez Hill, along the Cherry Hill fault, north of Signal Hill and in the Lakewood area. From these areas the water is removed by pumping for industrial, irrigation, and domestic uses.

The movement of ground water across the Los Angeles-Orange County line, which forms the eastern boundary of the Central Basin, is entirely dependent on the hydraulic gradient in that area, as no physical barrier to ground water movement exists except for the Coyote Hills.

Transmissibility rates of aquifers in Central Basin as shown on Plates 26A through 26I are extremely variable, ranging up to 400,000 gallons per day per foot of width, although most of the aquifers have transmissibility rates of less than 100,000.

The Gaspur aquifer (Plate 26A) generally has a transmissibility rate of less than 200,000 gallons per day per foot, but has a maximum of 400,000 in a small area in Whittier Narrows. Transmissibility rates in the Artesia-Exposition aquifer average about 30,000 with a maximum transmissibility rate of about 70,000 in several small areas (see Plate 26B, "Lines of Equal Transmissibility of the Artesia-Exposition Aquifers"). The Gage and Gardena aquifers (Plate 26C) also have average rates of about 30,000 but reach a maximum value of about 100,000 near Long Beach and in the Whittier Narrows. The transmissibility rates of the Hollydale and Jefferson aquifers, shown on Plates 26D and 26E entitled, "Lines of Equal Transmissibility of the Hollydale Aquifer" and "Lines of Equal Transmissibility of the Jefferson Aquifer", respectively, have average values of about 20,000 gallons per day per foot of width. The Lynwood aquifer rates (Plate 26F) average about 40,000 but attain a maximum transmissibility rate of about 100,000 gallons per day per foot of width in several areas.

The Silverado aquifer (Plate 26G) averages about 60,000 but reaches a maximum of 400,000 near the intersection of Carson and Atlantic Boulevards. Data on the Sunnyside aquifer in the middle, deeper portion of Central Basin is not very complete, but it appears to have an average transmissibility rate of about 100,000 with a maximum of 300,000 in several areas as shown on Plate 26H, "Lines of Equal Transmissibility of the Sunnyside Aquifer".

The overall transmissibility of all aquifers in the Central Basin is of considerable importance. It may be noted on Plate 26I that high transmissibility rates exist from Whittier Narrows toward Long Beach and Compton, but that an area of low transmissibility separates the Montebello and Los Angeles Forebays. This low transmissibility partly explains the existence of the large pumping depression around Huntington Park and Vernon, where pumping rates are generally not much higher than in the Downey area but there no pumping depression exists.

While the Central Basin Pressure Area is, as its name signifies, essentially an area of confined aquifers, free ground water conditions exist in the Semiperched aquifer overlying the Bellflower aquiclude, and probably in the vicinity of Baldwin Hills where the San Pedro formation is exposed at the surface. In addition, changes in ground water storage have occurred immediately south of the two forebay areas in the upper aquifers directly underlying the Bellflower aquiclude.

In past ground water studies of the Central Basin, it was believed that the clay layer or cap covered all of the basin south of the forebay areas and effectively prevented any percolation of surface water into the aquifers below. Plate 9 shows places where this clay cap, the Bellflower aquiclude, contains considerable amounts of sand and gravel. In these areas, water applied on the surface could percolate down into the underlying aquifers and it is possible that free ground water conditions may exist from the surface down through one or more of the upper aquifers. These areas increase the total area of the Central Basin where changes in ground water storage can occur with changing water levels and where replenishment by deep percolation can occur. In addition, changes in storage in the Bellflower aquiclude itself is believed to occur as water levels are lowered. These changes in storage are relatively small however, because of the relatively low specific yield assigned to much of these sediments.

Total capacity to store ground water in the Central Basin above the base of the Sunnyside aquifer, or the Silverado aquifer where the Sunnyside is missing, is about 13,800,000 acre-feet. Historically utilized storage since 1904 amounts to about 780,000 acre-feet. As noted before, this change in storage has occurred primarily in the Montebello and Los Angeles Forebay Areas; however, some of the change in storage occurred in the pressure area immediately south of these areas where water levels were lowered below the base of the Bellflower aquiclude and near the Repetto and Whittier Hills where the San Pedro formation crops out at the surface. The storage capacity between high water levels, which occurred in 1904, and sea level amounts to about 1,340,000 acre-feet.

The storage and storage change for the Central Basin listed above may be broken down between the generalized areas delineated on Plate 2 as follows:

	Total storage to base of deepest aquifer	Storage between high water and sea level	Historically utilized storage
Los Angeles Forebay Area	1,800,000	430,000	190,000
Montebello Forebay Area	1,800,000	410,000	230,000
Whittier Area	600,000	60,000	20,000
Central Basin Pressure Area	9,600,000	440,000	340,000
Total	13,800,000	1,340,000	780,000

CHAPTER VII. CONCLUDING REMARKS

This report has been compiled primarily for use in studies of ground water hydrology, quality, and basin operation. While it is true that considerable detail is shown on the plates and discussed in the text, the emphasis has been on general relationships between the aquifers, geologic structures, and ground water. Detailed investigations of small areas may indicate that there are, in reality, many more aquifers, and that their relationships are more complex than outlined here. It is to be expected that many of the details presented in this report will eventually be revised. However, it is believed that this report provides a foundation for further refinement and revision of the geology of the fresh water-bearing sediments.

Before additional refinements and revisions can be made it will be necessary to accumulate more basic data. Accordingly the following observations and recommendations are proffered:

1) This study has shown the value of the continuous collection of geologic and hydrologic data in order to better understand the physical limits of ground water basins, their aquifers and structures, and the movement and occurrence of their contained ground water. Where detailed information was available, the geologic interpretation was easier and certain, but not necessarily final. Areas that were deficient in data required an extension of basic concepts from known areas into unknown areas. It was here that the experience gained from similar studies in Southern California proved of value.

Development of highland areas is expanding and more wells are being drilled in volcanic rocks, older sediments, and the alluvium of mountain valleys. Although these areas are not in the principal ground water basins, the increased requests by the public for information on the ground water resources in the highlands have shown a need for more study of these upland areas.

It is therefore recommended that the data collection program be continued for areas both in the principal ground water basins as well as the lesser basins and highland areas. With more detailed information, the complex problems which will arise as ground water usage increases will be easier to analyze and perhaps solve. A continuous program of limited data collecting will also be necessary for a re-evaluation of areas already studied.

2) Similar studies of adjacent areas should clarify marginal basin features in the Coastal Plain of Los Angeles County. The regional interpretation sometimes sheds light on the local conditions. Conversely, information gained in this investigation will facilitate studies in these adjacent areas.

3) There is a need for more exploratory wells in areas where data is now deficient, in areas of sea-water intrusion, and in areas of complex geologic structures. These wells should be carefully logged by geologists, soil samples taken and examined for fossil or microfossil content, and water samples analyzed for water quality changes both in the vertical sequence of aquifers and laterally. Upon completion of the wells they should be pumped for transmissibility tests and to verify barrier effects, if any, of geologic structures.

4) There is a need for more control over the abandonment of water wells, such as the control that now exists in the oil well program,

to protect the aquifers containing good quality water from degradation or contamination from the surface or from other aquifers of poorer quality water.

5) As more information becomes available for the deeper Pliocene water-bearing materials, aquifers should be delineated and identified.

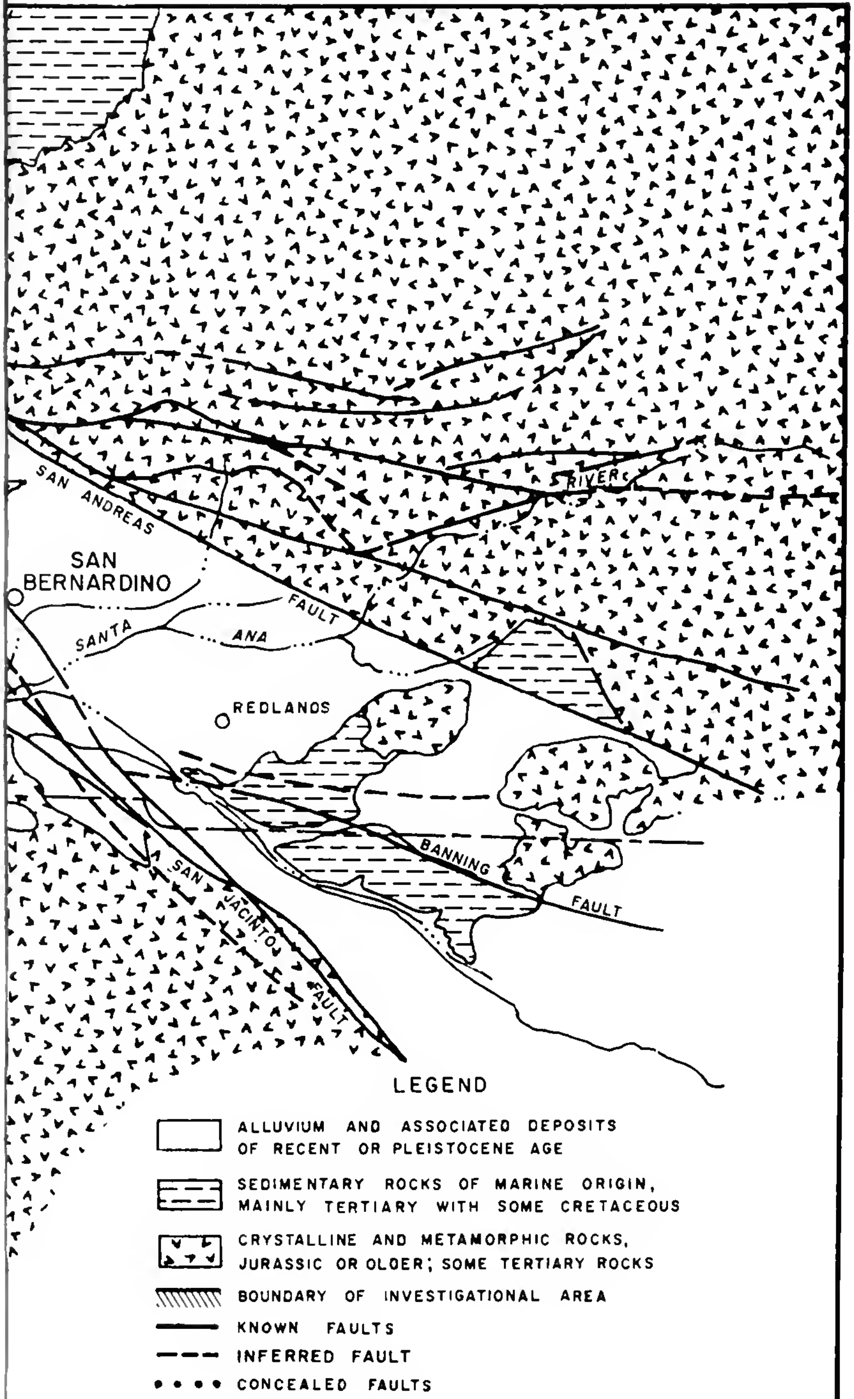
6) The present communication and cooperation between agencies conducting geologic and ground water investigations in Southern California should be continued and improved. This reduces the cost of future studies and eliminates duplication of effort.

)UNTY

s 1954)	Signal Hill Area (After Delong, 1941)		Coastal Plain of Los Angeles County (this report)	
ium and stream ces 10 ft.	Not shown in report		Alluvium	Gravel, sands, silt and clay
			Active Dune sand	White or gray well sorted sand
lluvium of d sands, silts, and dark gumbo . thick	Palos Verdes sands	Micaceous sand and gray gravel 20 ft. thick	Older Dune sand	Fine-to-medium sand with sandy silt, and gravel lenses
			Lakewood formation	Marine and continental gravel, sand, sandy silt, silt, and clay with shale pebbles
	(Unconformity)			
e sand and l, cross-bed- slumping, clay with reeds t. thick	San Pedro sands	Unconsolidated brown-gray sand 15 ft. thick. Coarse gray-brown sand, brown gravel 20 ft. thick.	San Pedro formation	Marine and continental gravel, sand, sandy silt, silt and clay
rown silt and concretions, s abundant. t. thick		Fine unconsolidated brown and gray sands 40 ft. thick	Undiff. San Pedro formation and/or Pico formation	Marine, partly consolidated gravel, sand, silt and clay
	(Unconformity)			
	Pico formation	Sandstone, sandy shale and shale 1300± ft. thick	Pico formation	Marine sand, silt, and clay interbedded with gravels
	Repetto formation	Sands and shales 2300± ft. thick	Repetto formation	Marine siltstone with layers of sandstone and conglomerate
missing	Hard black shale oil bearing		Miocene sediments and volcanics	Modelo formation (Santa Monica Mts.) Monterey formation (Palos Verdes Hills) Puente formation (Elysian, Repetto and Puente Hills)
	Not exposed or missing		Vaqueros and Sespe formations	Continental red conglomerate and sandstone
			Martinez formation	Marine conglomerate, sandstone, sandy shale and shale
			Undivided Martinez and Chico formations	
			Chico formation and intrusives	Marine hard conglomerate, sandstone and shale Continental conglomerate and sandstone
			Catalina schist	Varied schistose rocks
			Santa Monica slate	Slates, mica schists with quartz veins

SELECTED GEOLOGIC COLUMNAR SECTIONS IN AND NEAR THE COASTAL PLAIN OF LOS ANGELES COUNTY

Era	System	Series	Palos Verdes Hills (After Woodring and others, 1946)		Torrance-Santa Monica Area (After Poland and others, 1959a)		West Basin (D.W.R., 1952a)		Santa Monica Mountains (After Hoots, 1931)		Repetto and Montebello Hills (After Quarles, 1940)		South of Whittier Fault (After Hundert, 1952)		Coyote Hills (After Hoskins, 1954)		Signal Hill Area (After Delong, 1941)		Coastal Plain of Los Angeles County (this report)	
Cenozoic	Quaternary	Recent	Alluvium	Thin stringers in small canyons (Local unconformity)	Alluvial, coastal and dune deposits	Unconsolidated sand, gravel, silt and clay of lagoonal and fluvial origin. 0-175 ft. thick (Unconformity)	Alluvium Floodplain deposits Lagoonal marshlands Beach deposits Playa lake deposits Dune sand	0-200 ft. thick 0-150 ft. thick 0-25± ft. thick 0-25± ft. thick 0-20± ft. thick 0-200 ft. thick (Local unconformity)	Alluvium	Breccia, conglomerate, sandstone and silt	Alluvium		Alluvium	Unconsolidated gray gravel, sand and silt	Alluvium	Alluvium and stream terraces 10 ft. thick	Not shown in report		Alluvium Active Dune sand	Gravel, sands, silt and clay White or gray well sorted sand
		Pleistocene, Upper	Palos Verdes sand	Nonmarine and marine terrace deposits	Terrace cover and Palos Verdes sand Unnamed upper Pleistocene deposits	Nonmarine, red-brown sand, silt, and soil, underlain by marine sand and gravel, 50 ft. thick Gravel, sand, silt, and clay of fluvial and marine origin (Local unconformity)	Terrace Cover Palos Verdes sand Unnamed upper Pleistocene	0-20 ft. thick 0-50 ft. thick Upper fine-grained 0-300 ft. thick Lower coarse-grained 0-250 ft. thick (Local unconformity)	Alluvial Plain deposits Marine Upper Pleistocene	Red-brown breccia conglomerate and sandstone, earthy matrix. 0-300 ft. thick Fossilif. gray sandstone, sandy claystone, conglomerate. 5-100 ft. thick (Unconformity)	Terrace	Red sandy conglomerate, poorly sorted	La Habra formation	Nonmarine conglomerate, gravel, sand, silt; poorly consolidated, cross-bedded 1500 (?) ft. thick	Upper Pleistocene Sunny Hills formation	Old alluvium of bedded sands, silts, clay and dark gumbo 40 ft. thick	Palos Verdes sands	Micaceous sand and gray gravel 20 ft. thick (Unconformity)	Older Dune sand Lakewood formation	Fine-to-medium sand with sandy silt, and gravel lenses Marine and continental gravel, sand, sandy silt, silt, and clay with shale pebbles
		Pleistocene, Lower	San Pedro sand Timms Point silt Lomita marl		San Pedro formation including Timms Point silt and Lomita marl	Unconsolidated to consolidated gravels, sand, silt, and clay (marine to fluvial origin) (Local unconformity)	San Pedro formation (San Pedro sand, Timms Point silt, Lomita marl)	0-400 ft. thick (Local unconformity)	Lower Pleistocene (or upper Pliocene)	Fossiliferous. Conglomerate, sandstone and sandy clay. 100 ft. thick (Unconformity)	Saugus	Nonmarine and marine conglomerates, sand, silt. 65 ft. thick		(Unconformity)	San Pedro sand Coyote silt	Marine sand and gravel, cross-bedding, slumping, clay beds with reeds 300 ft. thick Tan-brown silt and sand, concretions, shells abundant. 145 ft. thick	San Pedro sands	Unconsolidated brown-gray sand 15 ft. thick, coarse gray-brown sand, brown gravel [illegible] ft. thick. Fine unconsolidated brown and gray sands 40 ft. thick (Unconformity)	San Pedro formation Undiff., San Pedro formation and/or Pico formation	Marine and continental gravel, sand, sandy silt, silt and clay Marine, partly consolidated gravel, sand, silt and clay
	Tertiary	Pliocene	Repetto siltstone		Pico formation	Semiconsol. marine sand, silt, gravel 0-1000 ft. thick Marine sand, siltstone and claystone, 0-1200 ft. thick Marine sand, siltstone and claystone, 0-170 ft. thick (Local unconformity)	Upper Pico formation (Local unconformity) Middle and lower Pico formation Repetto formation	0-1800 ft. thick 0-1700± ft. thick 0-4080 ft. thick (Local unconformity)	Upper Middle San Diego formation Lower	Clay, sandstone and limestone. 500 ft. thick Conglomerate sandstone. 0-35 ft. thick Clay, sandstone and limestone. 500 ft. thick (Unconformity)	Pico Repetto	Marine siltstone, conglomerate and sandstone Massive siltstone	Pico siltstone Upper Repetto Middle Repetto Lower Repetto	Sandy siltstone and silty sandstone. 5000 ft. Sandstone and conglomerate. 1100 ft. thick Sandy siltstone 1100 ft. thick Sandstone, siltstone and conglomerate 1000 ft. thick	Not exposed or missing		Pico formation Repetto formation	Sandstone, sandy shale and shale 1300± ft. thick Sands and shales 2300± ft. thick	Pico formation Repetto formation	Marine sand, silt, and clay interbedded with gravels Marine siltstone with layers of sandstone and conglomerate
		Miocene	Malaga mudstone Valmonte diatomite Altamira shale Unexposed subsurface lower Miocene		Monterey shale and Puente formation	Sandstone, siltstone and shale. 0-4500 ft. thick (Unconformity)	Monterey shale and Puente formation	0-4500 ft. thick (Local unconformity)	Upper Modelo formation (Unconformity) Middle Topanga formation Lower Vaqueros and Sespe	Marine shale and sandstone, volcanic ash. [illegible] ft. thick Marine sandstone, conglomerate, shale, and basalt. Conglomerate and sandstone, continental (Unconformity)	Puente	Upper shale Middle sandstone Lower shale	Hoover conglomerate Central Fee sandstone	Conglomerate with dark red matrix. 750 ft. thick Sandstone and siltstone. 1000 ft. thick			Hard black shale oil bearing		Miocene sediments and volcanics	Modelo formation (Santa Monica Mts.) Monterey formation (Palos Verdes Hills) Puente formation (Elysian, Repetto and Puente Hills)
		Oligocene	Missing		Missing		Missing		Missing		Not exposed or missing		Not exposed or missing				Not exposed or missing		Vaqueros and Sespe formations	Continental red conglomerate and sandstone
		Eocene							Martinez	Shale, sandstone, limestone, fossiliferous algal limestone reefs. 150 ft. thick									Martinez formation	Marine conglomerate, sandstone, sandy shale and shale
		Paleocene	Missing (Unconformity)						The Paleocene series not recognized by this author										Undivided Martinez and Chico formations	
Mesozoic	Cretaceous	Upper							Chico formation	Marine conglomerate sandstone and shale. 5000 ft. thick (Unconformity)									Chico formation and intrusives	Marine hard conglomerate, sandstone and shale Continental conglomerate and sandstone
	Jurassic (?)		Franciscan schist		Franciscan formation	Serpentine, talc, or schist	Franciscan		Granitic intrusion	Granite and granodiorite									Catalina schist	Varied schistose rocks
	Triassic (?)		Not Exposed		Not Exposed		Not exposed		Santa Monica slate	Slate and mica schist. 5000-7000 ft. thick									Santa Monica slate	Slates, mica schists with quartz veins



STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN CALIFORNIA DISTRICT

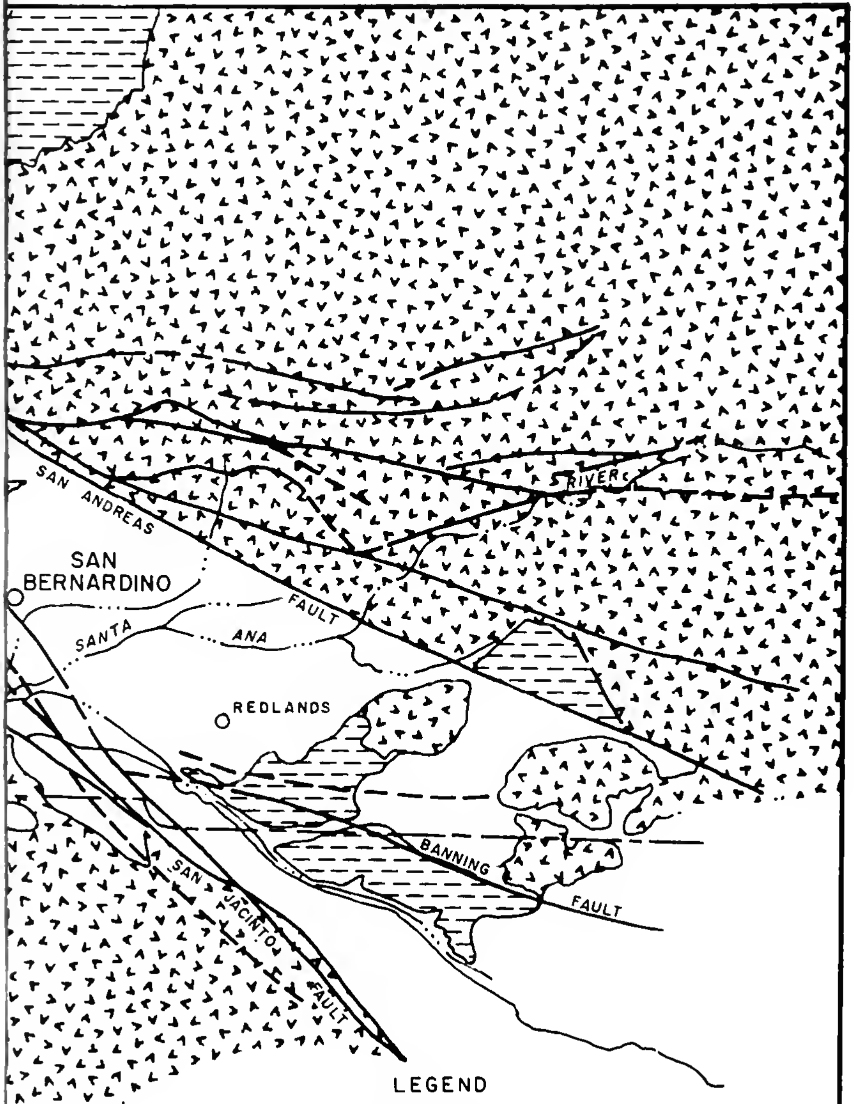
GROUND WATER GEOLOGY OF THE COASTAL PLAIN OF LOS ANGELES COUNTY

GENERAL GEOLOGY AND LOCATION OF AREA OF INVESTIGATION

SCALE OF MILES
5 0 5 10

1961

PLATE I



LEGEND

ALLUVIUM AND ASSOCIATED DEPOSITS OF RECENT OR PLEISTOCENE AGE

SEDIMENTARY ROCKS OF MARINE ORIGIN, MAINLY TERTIARY WITH SOME CRETACEOUS

CRYSTALLINE AND METAMORPHIC ROCKS, JURASSIC OR OLDER; SOME TERTIARY ROCKS

BOUNDARY OF INVESTIGATIONAL AREA

KNOWN FAULTS

INFERRED FAULT

CONCEALED FAULTS

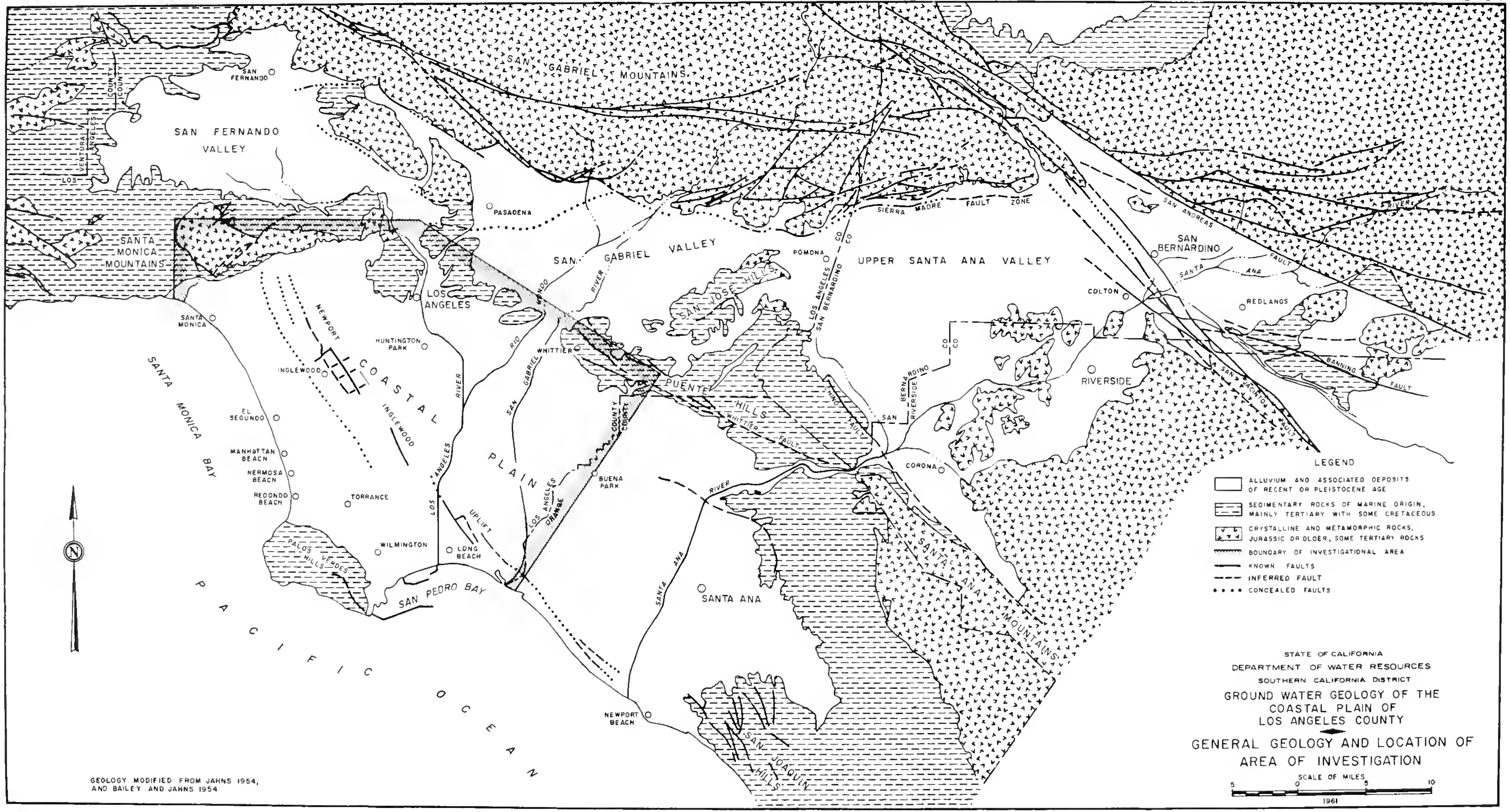
STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN CALIFORNIA DISTRICT

GROUND WATER GEOLOGY OF THE COASTAL PLAIN OF LOS ANGELES COUNTY

GENERAL GEOLOGY AND LOCATION OF AREA OF INVESTIGATION

SCALE OF MILES
5 0 5 10

1961



STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN CALIFORNIA DISTRICT
GROUND WATER GEOLOGY OF THE COASTAL PLAIN OF LOS ANGELES COUNTY

GENERAL GEOLOGY AND LOCATION OF AREA OF INVESTIGATION

N

LEGEND

BOUNDARY BETWEEN PHYSIOGRAPHIC FEATURES (DOTTED WHERE APPROXIMATE OR POORLY DEFINED)

BOUNDARY OF GROUND WATER BASIN

BOUNDARY OF FOREBAY AND WHITTIER AREA

AXIS OF SUBMARINE CANYON

BOUNDARY BETWEEN FOREBAY AND PRESSURE AREA FROM BULLETIN 45 (CALIF. D.W.R. 1934)

STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN CALIFORNIA DISTRICT

GROUND WATER GEOLOGY OF THE COASTAL PLAIN OF LOS ANGELES COUNTY

PHYSIOGRAPHIC FEATURES AND GROUND WATER BASINS

SCALE OF MILES

2 0 2 4

1961

PLATE 2

LEGEND

BOUNDARY BETWEEN PHYSIOGRAPHIC FEATURES (DOTTED WHERE APPROXIMATE OR POORLY DEFINED)

BOUNDARY OF GROUND WATER BASIN

BOUNDARY OF FOREBAY AND WHITTIER AREA

AXIS OF SUBMARINE CANYON

BOUNDARY BETWEEN FOREBAY AND PRESSURE AREA FROM BULLETIN 45 (CALIF. D W R 1934)

STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN CALIFORNIA DISTRICT

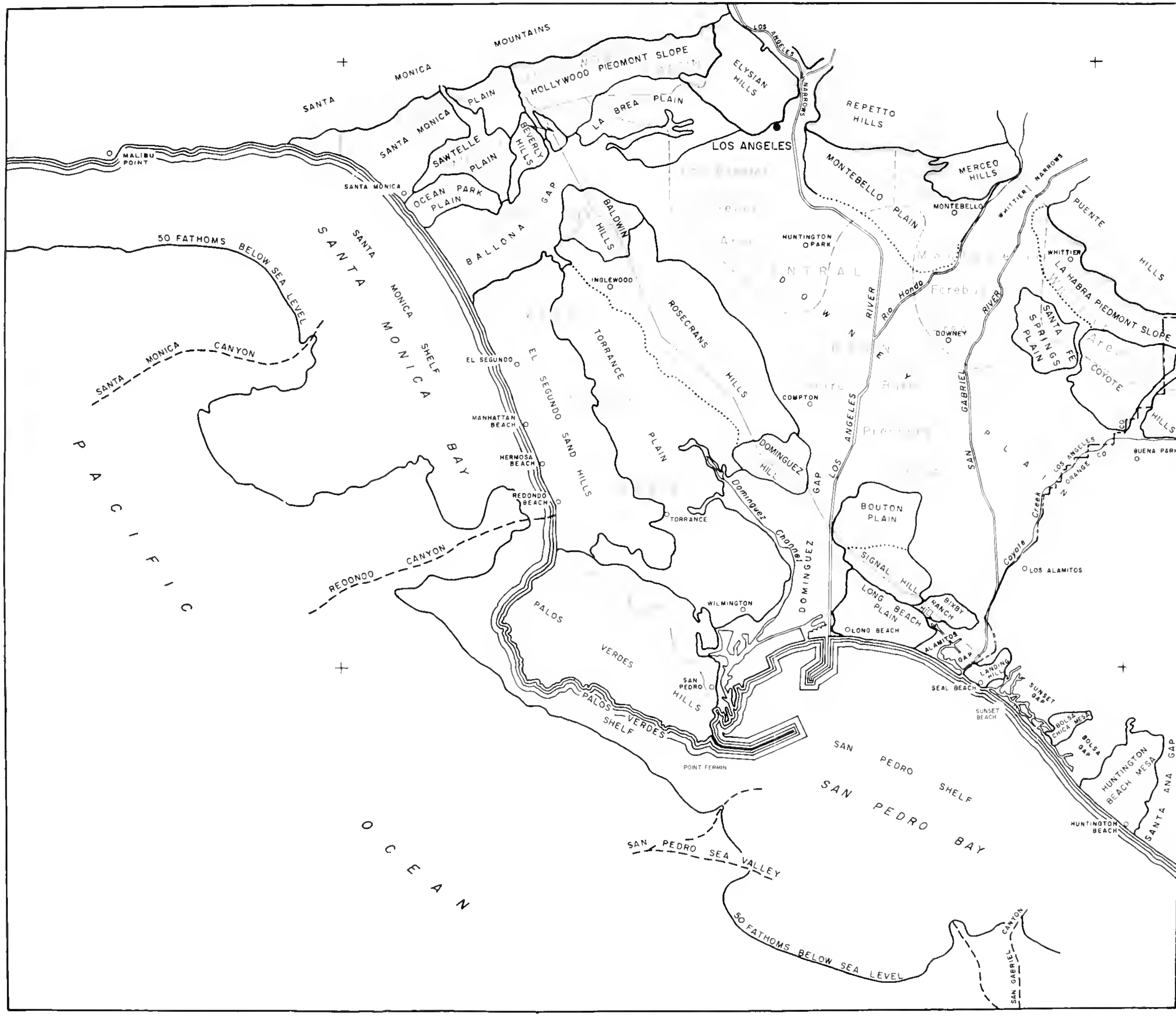
GROUND WATER GEOLOGY OF THE COASTAL PLAIN OF LOS ANGELES COUNTY

PHYSIOGRAPHIC FEATURES AND GROUND WATER BASINS

SCALE OF MILES

2 0 2 4

1951



N

LEGEND

BOUNDARY BETWEEN PHYSIOGRAPHIC FEATURES (DOTTED WHERE APPROXIMATE OR POORLY DEFINED)

BOUNDARY OF GROUND WATER BASIN

BOUNDARY OF FOREBAY AND WHITTIER AREA

AXIS OF SUBMARINE CANYON

BOUNDARY BETWEEN FOREBAY AND PRESSURE AREA FROM BULLETIN 45 (CALIF. D.W.R. 1934)

STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN CALIFORNIA DISTRICT

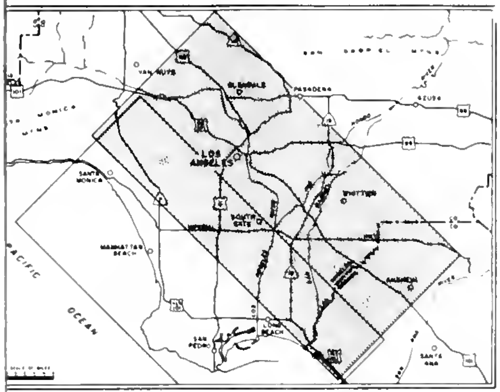
GROUND WATER GEOLOGY OF THE COASTAL PLAIN OF LOS ANGELES COUNTY

PHYSIOGRAPHIC FEATURES AND GROUND WATER BASINS

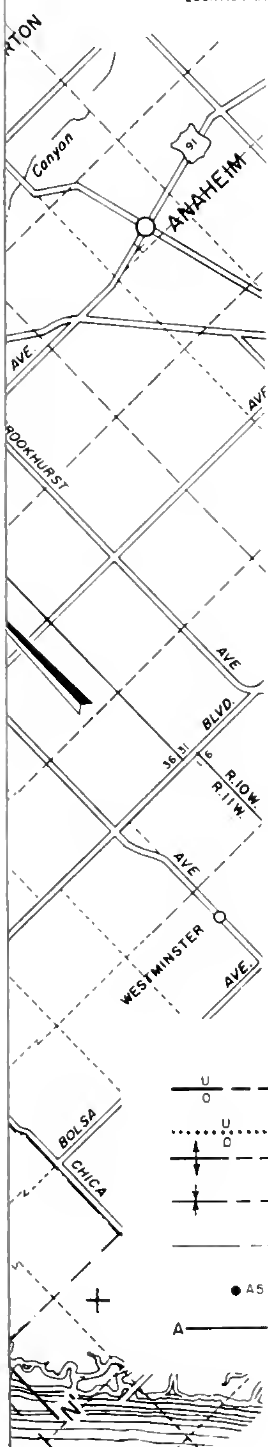
SCALE OF MILES

2 0 2 4

1961



LOCATION MAP



LEGEND

SEDIMENTARY ROCKS

QUATERNARY	RECENT		Qal	ALLUVIUM GRAVEL, SAND, SILT, AND CLAY
			Qsr	ACTIVE DUNE SAND WHITE OR GREYISH, WELL SORTED SAND
	PLEISTOCENE	UPPER	Qso	OLDER DUNE SAND FINE TO MEDIUM SAND WITH SILT, AND GRAVEL LENSES
			Qlw	LAKEWOOD FORMATION (INCLUDES "TERRACE DEPOSITS," "PALOS VERDES SAND," AND "UNNAMED UPPER PLEISTOCENE DEPOSITS") MARINE AND CONTINENTAL GRAVEL, SAND, SANDY SILT, SILT, AND CLAY WITH SHALE PEBBLES
		LOWER	Qsp	SAN PEDRO FORMATION (INCLUDES "LA HABRA CONGLOMERATE" AND PART OF "SAUGUS FORMATION") MARINE AND CONTINENTAL GRAVEL, SAND, SANDY SILT, SILT, AND CLAY
			Qsp-Pp	UNDIFFERENTIATED SAN PEDRO FORMATION AND/OR PICO FORMATION MARINE, PARTIALLY CONSOLIDATED GRAVEL, SAND, SILT, AND CLAY
TERTIARY	PLIOCENE		Pp	PICO FORMATION MARINE SAND, SILT, AND CLAY INTERBEDDED WITH GRAVEL
			Pr	REPETTO FORMATION MARINE SILTSTONE WITH LAYERS OF SANDSTONE AND CONGLOMERATE
	MIOCENE		Ms	(SANTA MONICA MOUNTAINS) MODELO FORMATION MARINE CONGLOMERATIC SANDSTONE, SANDSTONE, AND SHALE TOPANGA FORMATION MARINE CONGLOMERATE, SANDSTONE, AND SHALE (PALOS VERDES HILLS) MONTEREY FORMATION MUDSTONE, DIATOMITE, AND SHALE (ELYSIAN HILLS, REPETTO HILLS, AND PUENTE HILLS) PUENTE FORMATION MARINE SILTSTONE, SANDSTONE, SHALE, CONGLOMERATE, LIMESTONE, AND TUFF
	OLIGOCENE(?)		Φ	VAQUEROS AND SESPE FORMATIONS CONTINENTAL RED CONGLOMERATE AND SANDSTONE
	EOCENE		E	MARTINEZ FORMATION MARINE CONGLOMERATE, SANDSTONE, SANDY SHALE, AND SHALE
	PALEOCENE(?)		E-K	UNDIVIDED MARTINEZ AND CHICO FORMATIONS
CRETACEOUS	UPPER		Ks	CHICO FORMATION UPPER MARINE MEMBER-HARD CONGLOMERATE, SANDSTONE, AND SHALE LOWER CONTINENTAL MEMBER-RED CONGLOMERATE AND SANDSTONE

IGNEOUS AND METAMORPHIC ROCKS

TERTIARY	MIOCENE	Mv	MIDDLE MIOCENE VOLCANIC ROCKS VOLCANIC FLOWS, BRECCIAS, TUFFS, AND INTRUSIVES CHIEFLY BASALTIC AND ANDESITIC WITH OCCASIONAL ACID ROCKS GENERALLY ASSOCIATED WITH TOPANGA, MODELO, OR PUENTE FORMATIONS
CRETACEOUS	UPPER	Kg	(SANTA MONICA MOUNTAINS) INTRUSIVES OF GRANITE AND GRANODIORITE
JURASSIC		J	(PALOS VERDES HILLS) CATALINA SCHIST COMPARED WITH FRANCISCAN FORMATION OF THE COAST RANGES VARIED TYPES OF SCHISTOSE ROCKS
TRIASSIC		₮	SANTA MONICA SLATE GREY TO BLACK SLATE, SPOTTED SLATE, MICA SCHIST WITH QUARTZ VEINS

LEGEND

- U / D — FAULT (DASHED WHERE APPROXIMATLY LOCATED; U-UPTHROWN SIDE; D-DOWNTHROWN SIDE)
- CONCEALED FAULT
- ANTICLINE (DASHED WHERE APPROXIMATLY LOCATED.
- SYNCLINE (DASHED WHERE APPROXIMATLY LOCATED.
- CONTACT (DASHED WHERE APPROXIMATLY LOCATED.
- ● A5 WELLS USED IN PREPARATION OF GEOLOGIC SECTIONS.
- A——A' LINE LOCATION OF GEOLOGIC SECTIONS SHOWN ON PLATES 6A THROUGH 6G

STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN CALIFORNIA DISTRICT

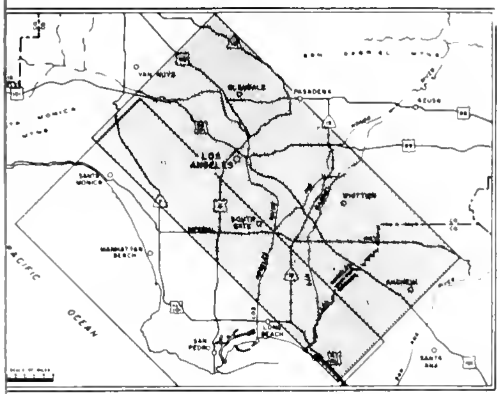
GROUND WATER GEOLOGY OF THE COASTAL PLAIN OF LOS ANGELES COUNTY

AREAL GEOLOGY

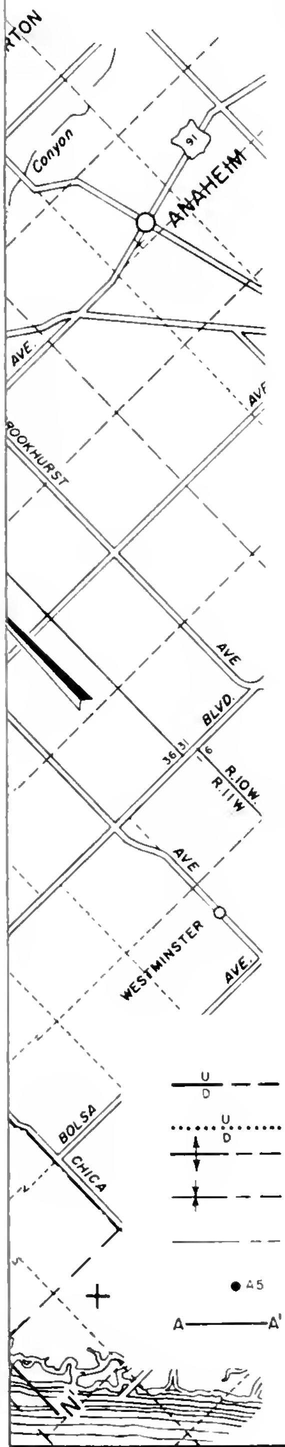
SCALE OF MILES

1 0 1 2 3

1961



LOCATION MAP



LEGEND

SEDIMENTARY ROCKS

QUATERNARY	RECENT	Qal	ALLUVIUM — GRAVEL, SAND, SILT, AND CLAY
	RECENT	Qsr	ACTIVE DUNE SAND — WHITE OR GREYISH, WELL SORTED SAND
	PLEISTOCENE, UPPER	Qso	OLDER DUNE SAND — FINE TO MEDIUM SAND WITH SILT, AND GRAVEL LENSES
	PLEISTOCENE, UPPER	Qlw	LAKEWOOD FORMATION (INCLUDES "TERRACE DEPOSITS," "PALOS VERDES SAND," AND "UNNAMED UPPER PLEISTOCENE DEPOSITS") — MARINE AND CONTINENTAL GRAVEL, SAND, SANDY SILT, SILT, AND CLAY WITH SHALE PEBBLES
	PLEISTOCENE, LOWER	Qsp	SAN PEDRO FORMATION (INCLUDES "LA HABRA CONGLOMERATE" AND PART OF "SAUGUS FORMATION") — MARINE AND CONTINENTAL GRAVEL, SAND, SANDY SILT, SILT, AND CLAY
TERTIARY		Qsp-Pp	UNDIFFERENTIATED SAN PEDRO FORMATION AND/OR PICO FORMATION — MARINE, PARTIALLY CONSOLIDATED GRAVEL, SAND, SILT, AND CLAY
	PLIOCENE	Pp	PICO FORMATION — MARINE SAND, SILT, AND CLAY INTERBEDDED WITH GRAVEL
	PLIOCENE	Pr	REPETTO FORMATION — MARINE SILTSTONE WITH LAYERS OF SANDSTONE AND CONGLOMERATE
	MIOCENE	Ms	(SANTA MONICA MOUNTAINS) MODELO FORMATION — MARINE CONGLOMERATIC SANDSTONE, SANDSTONE, AND SHALE; TOPANGA FORMATION — MARINE CONGLOMERATE, SANDSTONE, AND SHALE; (PALOS VERDES HILLS) MONTEREY FORMATION — MUDSTONE, DIATOMITE, AND SHALE; (ELYSIAN HILLS, REPETTO HILLS, AND PUENTE HILLS) PUENTE FORMATION — MARINE SILTSTONE, SANDSTONE, SHALE, CONGLOMERATE, LIMESTONE, AND TUFF
	OLIGOCENE(?)	Φ	VAQUEROS AND SESPE FORMATIONS — CONTINENTAL RED CONGLOMERATE AND SANDSTONE
	EOCENE	E	MARTINEZ FORMATION — MARINE CONGLOMERATE, SANDSTONE, SANDY SHALE, AND SHALE
	PALEOCENE(?)	E-K	UNDIVIDED MARTINEZ AND CHICO FORMATIONS
CRETACEOUS	UPPER	Ks	CHICO FORMATION — UPPER MARINE MEMBER-HARD CONGLOMERATE, SANDSTONE, AND SHALE; LOWER CONTINENTAL MEMBER-RED CONGLOMERATE AND SANDSTONE

IGNEOUS AND METAMORPHIC ROCKS

TERTIARY	MIOCENE	Mv	MIDDLE MIOCENE VOLCANIC ROCKS — VOLCANIC FLOWS, BRECCIAS, TUFFS, AND INTRUSIVES CHIEFLY BASALTIC AND ANDESITIC WITH OCCASIONAL ACID ROCKS GENERALLY ASSOCIATED WITH TOPANGA, MODELO, OR PUENTE FORMATIONS
CRETACEOUS	UPPER	Kg	(SANTA MONICA MOUNTAINS) INTRUSIVES OF GRANITE AND GRANODIORITE
JURASSIC		J	(PALOS VERDES HILLS) CATALINA SCHIST COMPARED WITH FRANCISCAN FORMATION OF THE COAST RANGES VARIED TYPES OF SCHISTOSE ROCKS
TRIASSIC		Ћ	SANTA MONICA SLATE — GREY TO BLACK SLATE, SPOTTED SLATE, MICA SCHIST WITH QUARTZ VEINS

LEGEND

- U/D — FAULT (DASHED WHERE APPROXIMATLY LOCATED; U-UPTHROWN SIDE; D-DOWNTHROWN SIDE)
- U/D — CONCEALED FAULT
- ANTICLINE (DASHED WHERE APPROXIMATLY LOCATED.
- SYNCLINE (DASHED WHERE APPROXIMATLY LOCATED.
- CONTACT (DASHED WHERE APPROXIMATLY LOCATED.
- ● 45 — WELLS USED IN PREPARATION OF GEOLOGIC SECTIONS.
- A——A' — LINE LOCATION OF GEOLOGIC SECTIONS SHOWN ON PLATES 6A THROUGH 6G

STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN CALIFORNIA DISTRICT

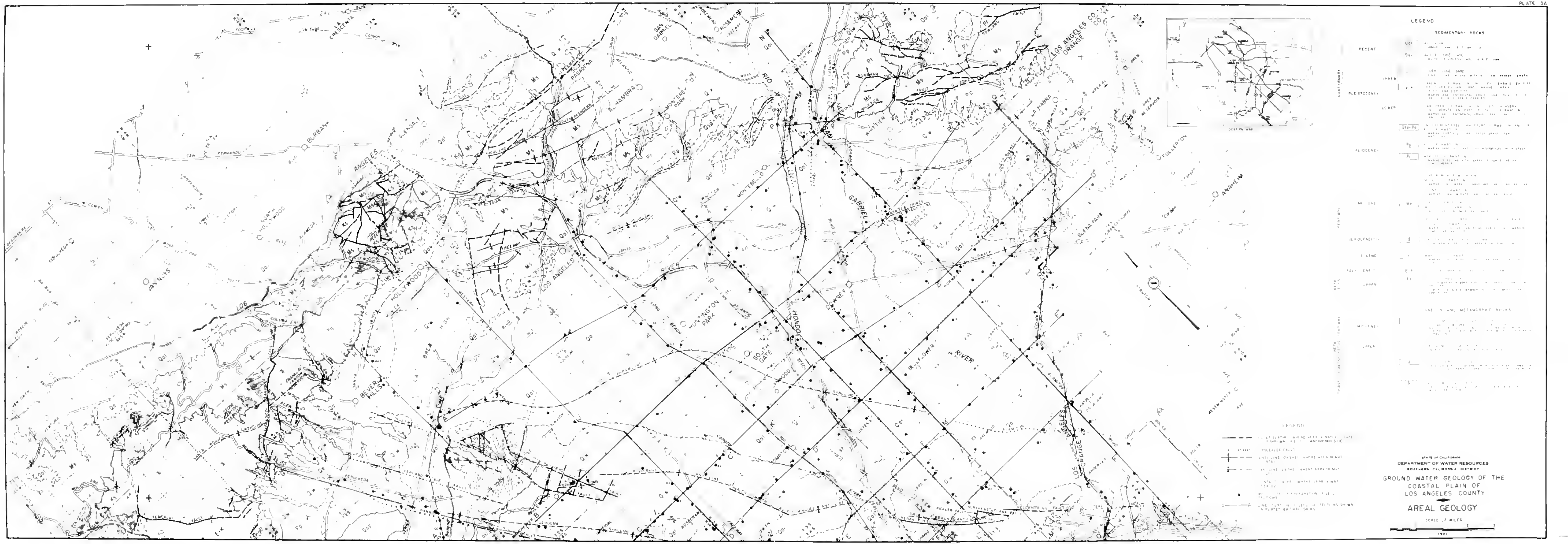
GROUND WATER GEOLOGY OF THE COASTAL PLAIN OF LOS ANGELES COUNTY

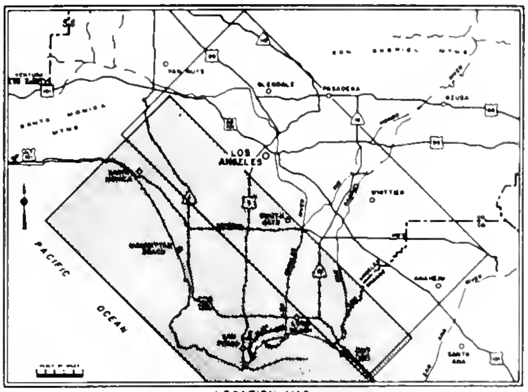
AREAL GEOLOGY

SCALE OF MILES

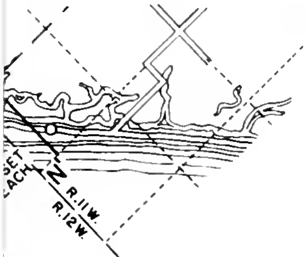
1 0 1 2 3

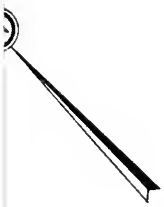
1961


LEGEND
SEDIMENTARY ROCKS
RECENT
QUATERNARY
PLEISTOCENE
UPPER
LOWER
PLIOCENE
MIOCENE
LOCATION MAP
LEGEND
BURBANK
GLENDALE
PASADENA
ALHAMBRA
MONTEREY PARK
SAN GABRIEL
ROSEMEAD
WHITTIER
LA HABRA
FULLERTON
ANAHEIM
BUENA PARK
DOWNEY
SOUTH GATE
HUNTINGTON PARK
LOS ANGELES
HOLLYWOOD
BEVERLY HILLS
VAN NUYS
NORTH HOLLYWOOD
LA CRESCENTA
LOS ANGELES CO.
ORANGE CO.
RIO HONDO
SAN GABRIEL RIVER
LOS ANGELES RIVER
SAN FERNANDO
LONG BEACH
LA BREA
STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN CALIFORNIA DISTRICT
GROUND WATER GEOLOGY OF THE
COASTAL PLAIN OF
LOS ANGELES COUNTY
AREAL GEOLOGY
2
3
1961



LOCATION MAP





LEGEND

SEDIMENTARY ROCKS

QUATERNARY	RECENT	Qal	ALLUVIUM GRAVEL, SAND, SILT, AND CLAY
		Qsr	ACTIVE DUNE SAND WHITE OR GREYISH, WELL SORTED SAND
	PLEISTOCENE – UPPER	Qso	OLDER DUNE SAND FINE TO MEDIUM SAND WITH SILT, AND GRAVEL LENSES
		Qlw	LAKEWOOD FORMATION (INCLUDES "TERRACE DEPOSITS," "PALOS VERDES SAND," AND "UNNAMED UPPER PLEISTOCENE DEPOSITS") MARINE AND CONTINENTAL GRAVEL, SAND, SANDY SILT, SILT, AND CLAY WITH SHALE PEBBLES
	PLEISTOCENE – LOWER	Qsp	SAN PEDRO FORMATION (INCLUDES "LA HABRA CONGLOMERATE" AND PART OF "SAUGUS FORMATION") MARINE AND CONTINENTAL GRAVEL, SAND, SANDY SILT, SILT, AND CLAY
		Qsp-Pp	UNDIFFERENTIATED SAN PEDRO FORMATION AND/OR PICO FORMATION MARINE, PARTIALLY CONSOLIDATED GRAVEL, SAND, SILT, AND CLAY
TERTIARY	PLIOCENE	Pp	PICO FORMATION MARINE SAND, SILT, AND CLAY INTERBEDDED WITH GRAVEL
		Pr	REPETTO FORMATION MARINE SILTSTONE WITH LAYERS OF SANDSTONE AND CONGLOMERATE
	MIOCENE	Ms	(SANTA MONICA MOUNTAINS) MODELO FORMATION MARINE CONGLOMERATIC SANDSTONE, SANDSTONE, AND SHALE TOPANGA FORMATION MARINE CONGLOMERATE, SANDSTONE, AND SHALE (PALOS VERDES HILLS) MONTEREY FORMATION MUDSTONE, DIATOMITE, AND SHALE (ELYSIAN HILLS, REPETTO HILLS, AND PUENTE HILLS) PUENTE FORMATION MARINE SILTSTONE, SANDSTONE, SHALE, CONGLOMERATE, LIMESTONE, AND TUFF
	OLIGOCENE(?)	Φ	VAQUEROS AND SESPE FORMATIONS CONTINENTAL RED CONGLOMERATE AND SANDSTONE
	EOCENE	E	MARTINEZ FORMATION MARINE CONGLOMERATE, SANDSTONE, SANDY SHALE, AND SHALE
	PALEOCENE(?)	E-K	UNDIVIDED MARTINEZ AND CHICO FORMATIONS
CRETACEOUS	UPPER	Ks	CHICO FORMATION UPPER MARINE MEMBER-HARD CONGLOMERATE, SANDSTONE, AND SHALE LOWER CONTINENTAL MEMBER-RED CONGLOMERATE AND SANDSTONE

IGNEOUS AND METAMORPHIC ROCKS

TERTIARY	MIOCENE	Mv	MIDDLE MIOCENE VOLCANIC ROCKS VOLCANIC FLOWS, BRECCIAS, TUFFS, AND INTRUSIVES CHIEFLY BASALTIC AND ANDESITIC WITH OCCASIONAL ACID ROCKS GENERALLY ASSOCIATED WITH TOPANGA, MODELO, OR PUENTE FORMATIONS
CRETACEOUS	UPPER	Kg	(SANTA MONICA MOUNTAINS) INTRUSIVES OF GRANITE AND GRANODIORITE
JURASSIC		J	(PALOS VERDES HILLS) CATALINA SCHIST COMPARED WITH FRANCISCAN FORMATION OF THE COAST RANGES VARIED TYPES OF SCHISTOSE ROCKS
TRIASSIC		Ћ	SANTA MONICA SLATE GREY TO BLACK SLATE, SPOTTED SLATE, MICA SCHIST WITH QUARTZ VEINS

LEGEND

- FAULT (DASHED WHERE APPROXIMATLY LOCATED; U-UPTHROWN SIDE; D-DOWNTHROWN SIDE)
- CONCEALED FAULT
- ANTICLINE (DASHED WHERE APPROXIMATLY LOCATED.
- SYNCLINE (DASHED WHERE APPROXIMATLY LOCATED.
- CONTACT (DASHED WHERE APPROXIMATLY LOCATED.
- WELLS USED IN PREPARATION OF GEOLOGIC SECTIONS.
- -A' LINE LOCATION OF GEOLOGIC SECTIONS SHOWN ON PLATES 6A THROUGH 6G

STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN CALIFORNIA DISTRICT

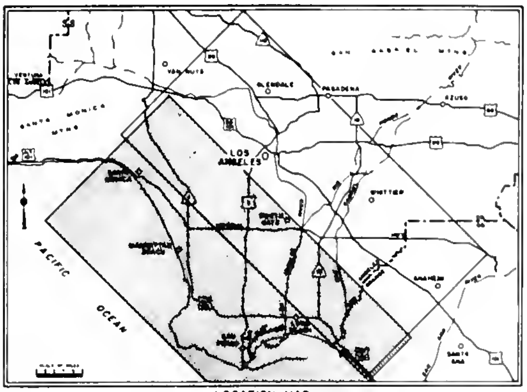
GROUND WATER GEOLOGY OF THE COASTAL PLAIN OF LOS ANGELES COUNTY

AREAL GEOLOGY

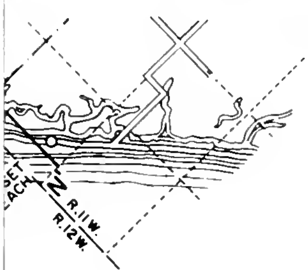
SCALE OF MILES

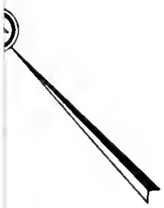
1 0 1 2 3

1961



LOCATION MAP





LEGEND

SEDIMENTARY ROCKS

QUATERNARY	RECENT	Qal	ALLUVIUM — GRAVEL, SAND, SILT, AND CLAY
		Qsr	ACTIVE DUNE SAND — WHITE OR GREYISH, WELL SORTED SAND
	PLEISTOCENE — UPPER	Qso	OLDER DUNE SAND — FINE TO MEDIUM SAND WITH SILT, AND GRAVEL LENSES
		Qlw	LAKEWOOD FORMATION (INCLUDES "TERRACE DEPOSITS," "PALOS VERDES SAND," AND "UNNAMED UPPER PLEISTOCENE DEPOSITS") — MARINE AND CONTINENTAL GRAVEL, SAND, SANDY SILT, SILT, AND CLAY WITH SHALE PEBBLES
	PLEISTOCENE — LOWER	Qsp	SAN PEDRO FORMATION (INCLUDES "LA HABRA CONGLOMERATE" AND PART OF "SAUGUS FORMATION") — MARINE AND CONTINENTAL GRAVEL, SAND, SANDY SILT, SILT, AND CLAY
		Qsp-Pp	UNDIFFERENTIATED SAN PEDRO FORMATION AND/OR PICO FORMATION — MARINE, PARTIALLY CONSOLIDATED GRAVEL, SAND, SILT, AND CLAY
TERTIARY	PLIOCENE	Pp	PICO FORMATION — MARINE SAND, SILT, AND CLAY INTERBEDDED WITH GRAVEL
		Pr	REPETTO FORMATION — MARINE SILTSTONE WITH LAYERS OF SANDSTONE AND CONGLOMERATE
	MIOCENE	Ms	(SANTA MONICA MOUNTAINS) MODELO FORMATION — MARINE CONGLOMERATIC SANDSTONE, SANDSTONE, AND SHALE; TOPANGA FORMATION — MARINE CONGLOMERATE, SANDSTONE, AND SHALE; (PALOS VERDES HILLS) MONTEREY FORMATION — MUDSTONE, DIATOMITE, AND SHALE; (ELYSIAN HILLS, REPETTO HILLS, AND PUENTE HILLS) PUENTE FORMATION — MARINE SILTSTONE, SANDSTONE, SHALE, CONGLOMERATE, LIMESTONE, AND TUFF
	OLIGOCENE(?)	Φ	VAQUEROS AND SESPE FORMATIONS — CONTINENTAL RED CONGLOMERATE AND SANDSTONE
	EOCENE	E	MARTINEZ FORMATION — MARINE CONGLOMERATE, SANDSTONE, SANDY SHALE, AND SHALE
	PALEOCENE(?)	E-K	UNDIVIDED MARTINEZ AND CHICO FORMATIONS
CRETACEOUS	UPPER	Ks	CHICO FORMATION — UPPER MARINE MEMBER-HARD CONGLOMERATE, SANDSTONE, AND SHALE; LOWER CONTINENTAL MEMBER-RED CONGLOMERATE AND SANDSTONE

IGNEOUS AND METAMORPHIC ROCKS

TERTIARY	MIOCENE	Mv	MIDDLE MIOCENE VOLCANIC ROCKS — VOLCANIC FLOWS, BRECCIAS, TUFFS, AND INTRUSIVES CHIEFLY BASALTIC AND ANDESITIC WITH OCCASIONAL ACID ROCKS GENERALLY ASSOCIATED WITH TOPANGA, MODELO, OR PUENTE FORMATIONS
CRETACEOUS	UPPER	Kg	(SANTA MONICA MOUNTAINS) INTRUSIVES OF GRANITE AND GRANODIORITE
JURASSIC		J	(PALOS VERDES HILLS) CATALINA SCHIST COMPARED WITH FRANCISCAN FORMATION OF THE COAST RANGES VARIED TYPES OF SCHISTOSE ROCKS
TRIASSIC		℞	SANTA MONICA SLATE — GREY TO BLACK SLATE, SPOTTED SLATE, MICA SCHIST WITH QUARTZ VEINS

LEGEND

- FAULT (DASHED WHERE APPROXIMATLY LOCATED; U-UPTHROWN SIDE; D-DOWNTHROWN SIDE)
- CONCEALED FAULT
- ANTICLINE (DASHED WHERE APPROXIMATLY LOCATED.
- SYNCLINE (DASHED WHERE APPROXIMATLY LOCATED.
- CONTACT (DASHED WHERE APPROXIMATLY LOCATED.
- WELLS USED IN PREPARATION OF GEOLOGIC SECTIONS.
- -A' LINE LOCATION OF GEOLOGIC SECTIONS SHOWN ON PLATES 6A THROUGH 6G.

STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN CALIFORNIA DISTRICT

GROUND WATER GEOLOGY OF THE COASTAL PLAIN OF LOS ANGELES COUNTY

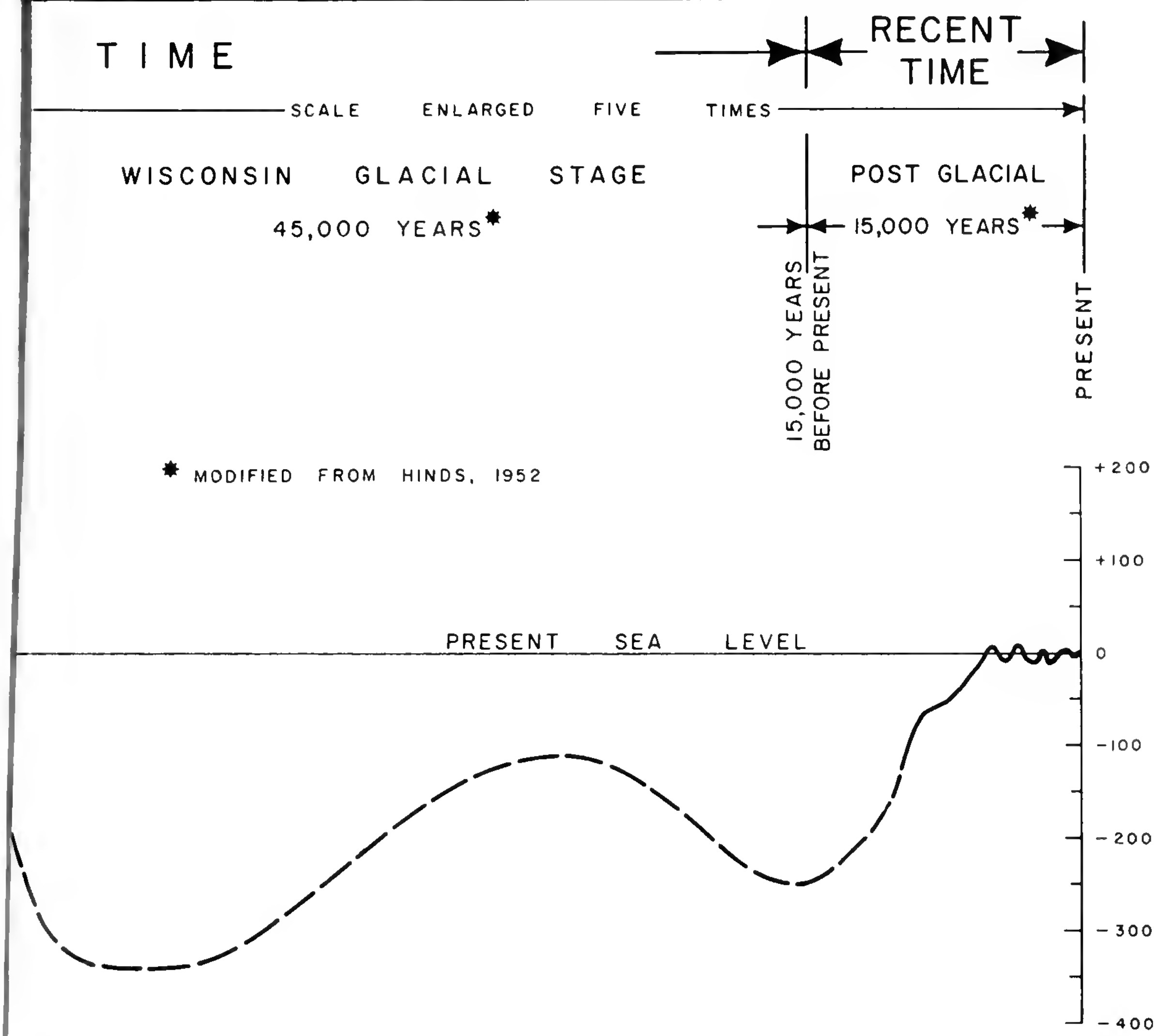
AREAL GEOLOGY

SCALE OF MILES

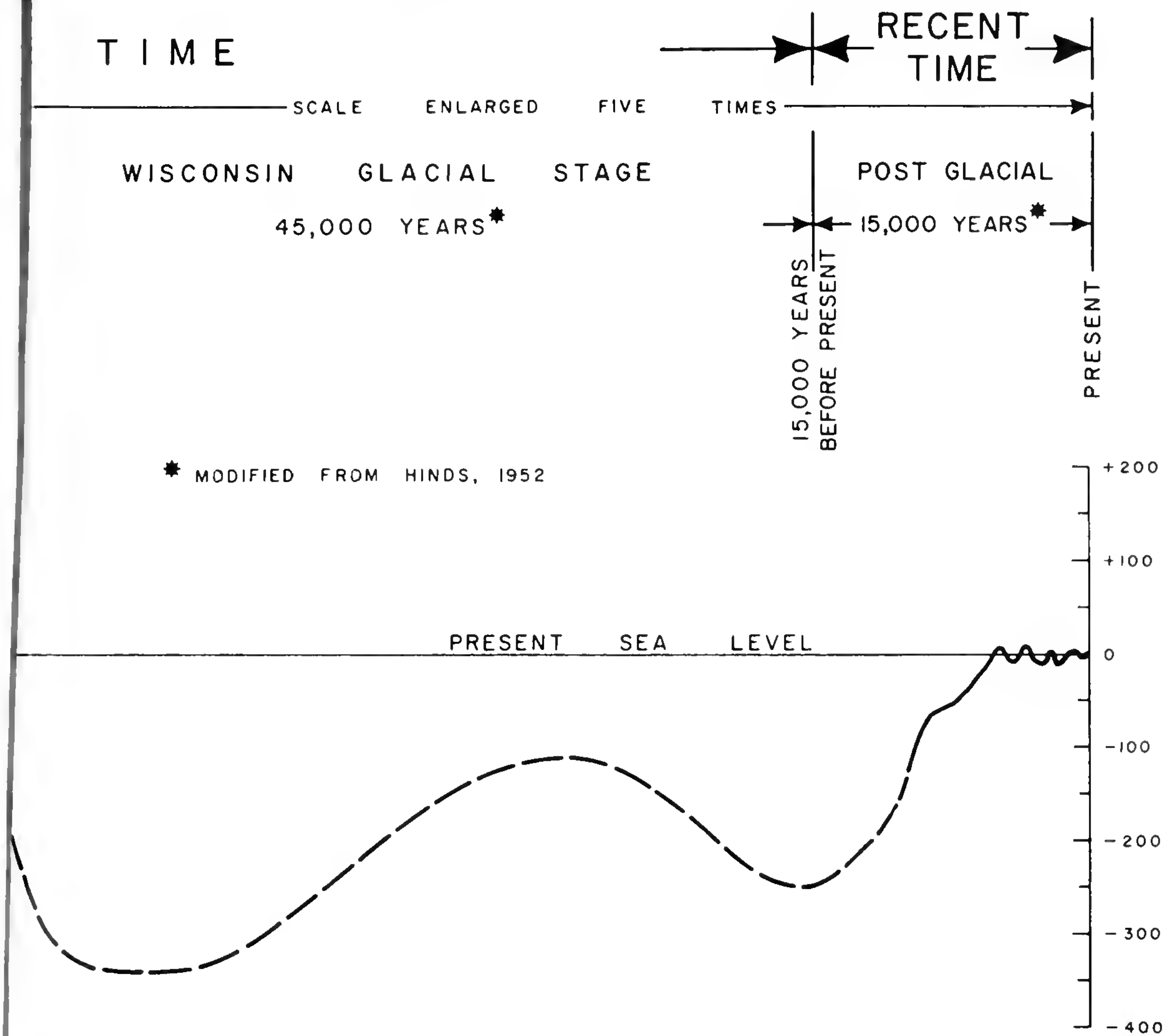
1 0 1 2 3

1961

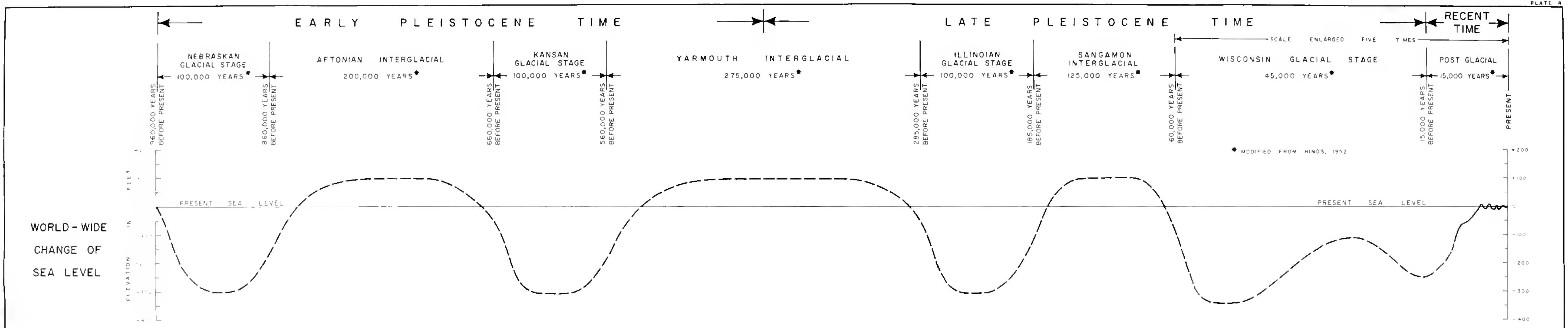

LEGEND
SEDIMENTARY ROCKS
RECENT
ACTIVE DUNE SAND
OLDER DUNE SAND
UPPER
PLEISTOCENE
QUATERNARY
MIOCENE
TERTIARY
OLIGOCENE(?)
EOCENE
PALEOCENE(?)
UPPER
IGNEOUS AND METAMORPHIC ROCKS
MIOCENE
UPPER
LOCATION MAP
SANTA MONICA
BEVERLY HILLS
LA BREA HIGH
INGLEWOOD
HAWTHORNE
EL SEGUNDO
MANHATTAN BEACH
HERMOSA BEACH
REDONDO BEACH
TORRANCE
SAN PEDRO
LONG BEACH
SOUTH GATE
LYNWOOD
BELLFLOWER
SAN GABRIEL
LOS ANGELES RIVER
ORANGE
SANTA MONICA BAY
PACIFIC OCEAN
SAN PEDRO BAY
STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN CALIFORNIA DISTRICT
GROUND WATER GEOLOGY OF THE
COASTAL PLAIN OF
LOS ANGELES COUNTY
AREAL GEOLOGY
SCALE OF MILES



FORMATION			RECENT DEPOSITION	
DUNE SAND O SAND HILLS) OSITED	EXPOSITION — ARTESIA AQUIFER DEPOSITED	DEPOSITION OF ACTIVE DUNE SAND INITIATED	GASPUR AQUIFER DEPOSITED	FINE — GRAINED ALLUVIUM EXPOSED OVER GASPUR AQUIFER
RTESIA UT; AND LTS D	LOS ANGELES AND SAN GABRIEL RIVERS ERODED UPPER PLEISTOCENE SEDIMENTS GAPS FORMED	GASPUR VALLEY CUT; STREAM EROSION OF UPPER PLEISTOCENE TERRACES		
NA DEPRESSION SUBSIDING				
PLEISTOCENE SEDIMENTS			RECENT DEFORMATION	
	SHORELINE FURTHER OFFSHORE THAN AT PRESENT		SHORELINE ADVANCING TO PRESENT POSITION	



FORMATION			RECENT DEPOSITION	
DUNE SAND (…O SAND HILLS) …OSITED	EXPOSITION — ARTESIA AQUIFER DEPOSITED	DEPOSITION OF ACTIVE DUNE SAND INITIATED	GASPUR AQUIFER DEPOSITED	FINE — GRAINED ALLUVIUM EXPOSED OVER GASPUR AQUIFER
…RTESIA …UT; … AND …LTS …D	LOS ANGELES AND SAN GABRIEL RIVERS ERODED UPPER PLEISTOCENE SEDIMENTS GAPS FORMED	GASPUR VALLEY CUT; STREAM EROSION OF UPPER PLEISTOCENE TERRACES		
…NA DEPRESSION SUBSIDING				
PLEISTOCENE SEDIMENTS			RECENT DEFORMATION	
	SHORELINE FURTHER OFFSHORE THAN AT PRESENT		SHORELINE ADVANCING TO PRESENT POSITION	



DEPOSITION	DEPOSITION OF SAN PEDRO FORMATION — CONTINUOUS IN DOWNFOLDED AREAS
	SUNNYSIDE AQUIFER DEPOSITED
	SILVERADO AQUIFER DEPOSITED
	FINE-GRAINED MARINE SEDIMENTS DEPOSITED OVER SILVERADO AQUIFER
	LINWOOD, JEFFERSON, AND HOLLYDALE AQUIFERS DEPOSITED
	DEPOSITION OF LAKEWOOD FORMATION
	GAGE AQUIFER DEPOSITED
	GARDENA AQUIFER DEPOSITED
	FINE-GRAINED MARINE SEDIMENTS DEPOSITED OVER GARDENA AQUIFER
	OLDER DUNE SAND (EL SEGUNDO SAND HILLS) DEPOSITED
	EXPOSITION — ARTESIA AQUIFER DEPOSITED
	DEPOSITION OF ACTIVE DUNE SAND INITIATED
	RECENT DEPOSITION
	GASPUR AQUIFER DEPOSITED
	FINE-GRAINED ALLUVIUM EXPOSED OVER GASPUR AQUIFER
EROSION	EROSION IN SOURCES AREAS
	EROSION OF SAN PEDRO FORMATION IN UPLIFTING AREAS
	HIATUS AND UNCONFORMITY BETWEEN UPPER AND LOWER PLEISTOCENE
	GARDENA CHANNEL CUT SAN PEDRO DEPOSITS ERODED, SECOND TERRACE ON PALOS VERDES HILLS CUT GAGE AQUIFER EXPOSED
	LOWEST TERRACES OF PALOS VERDES HILLS AND SANTA MONICA MTS CUT
	EXPOSITION — ARTESIA VALLEY CUT BEACH SANDS AND MARINE SILTS EXPOSED
	LOS ANGELES AND SAN GABRIEL RIVERS ERODED UPPER PLEISTOCENE SEDIMENTS GAPS FORMED
	GASPUR VALLEY CUT, STREAM EROSION OF UPPER PLEISTOCENE TERRACES
DEFORMATION	BORDERING HIGHLANDS RISING NEWPORT — INGLEWOOD UPLIFT DEVELOPING SOUTH GATE — SANTA ANA DEPRESSION SUBSIDING
	CONTEMPORANEOUS DEFORMATION OF LOWER PLEISTOCENE SEDIMENTS
	INCREASED DEFORMATION, HILLS EMERGING AND WIND GAPS FORMED
	CONTEMPORANEOUS DEFORMATION OF PLEISTOCENE SEDIMENTS
	RECENT DEFORMATION
POSITION OF SHORELINE	SHORELINE ALONG SOUTH SIDE OF SANTA MONICA MOUNTAINS ACROSS SAN GABRIEL VALLEY TO SANTA ANA MOUNTAINS REPETTO MERCED, AND PUENTE HILLS SHALLOW OFFSHORE FEATURES PALOS VERDES HILLS SUBMERGED
	SHORELINE FLUCTUATING FROM SOUTH FLANK OF SANTA MONICA MOUNTAINS AND ELYSIAN, REPETTO MERCED AND PUENTE HILLS TO PRESENT COASTLINE BUT GENERALLY RETREATING
	SHORELINE FURTHER OFFSHORE THAN AT PRESENT
	SHORELINE ADVANCING TO PRESENT POSITION

GENERALIZED PLEISTOCENE CHRONOLOGY
COASTAL PLAIN OF LOS ANGELES COUNTY

THICKNESS (FEET)	PREVIOUS FORMATION NAMES ✱	PREVIOUS AQUIFER NAMES ✱
60	ALLUVIUM	SEMIPERCHED †
140		
120		GASPUR †
- 40	TERRACE COVER	"50 FOOT GRAVEL"
200	PALOS VERDES SAND	SEMIPERCHED †
140	UNNAMED UPPER PLEISTOCENE	
160		GARDENA †
160		"200 FOOT SAND"
	LOCAL UNCONFORMITY	
100	SAN PEDRO FORMATION	
140		
200		"400 FOOT GRAVEL" †
500		SILVERADO †
500		
	PICO FORMATION	

LEGEND OF LITHOLOGY

GRAVEL AND SAND

SAND

SILTY OR SANDY CLAY

CLAY OR SHALE

✱ DESIGNATIONS AND TERMS UTILIZED IN "REPORT OF REFEREE" DATED JUNE 1952 PREPARED BY THE STATE ENGINEER COVERING THE WEST COAST BASIN

† DESIGNATED AS "WATER BEARING ZONES" IN ABOVE NOTED REPORT OF REFEREE

IGRAPHIC COLUMN
)S ANGELES COUNTY

THICKNESS FEET)	PREVIOUS FORMATION NAMES✸	PREVIOUS AQUIFER NAMES✸
60		SEMIPERCHED†
140	ALLUVIUM	
120		GASPUR†
- 40		"50 FOOT GRAVEL"
	TERRACE COVER	
200	PALOS VERDES SAND	SEMIPERCHED†
140	UNNAMED	
	UPPER	
160	PLEISTOCENE	GARDENA†
160		"200 FOOT SAND"
	LOCAL UNCONFORMITY	
100		
140	SAN	
200		"400 FOOT GRAVEL"†
	PEDRO	
500		SILVERADO †
	FORMATION	
500		
	PICO	
	FORMATION	

LEGEND OF LITHOLOGY

GRAVEL AND SAND

SAND

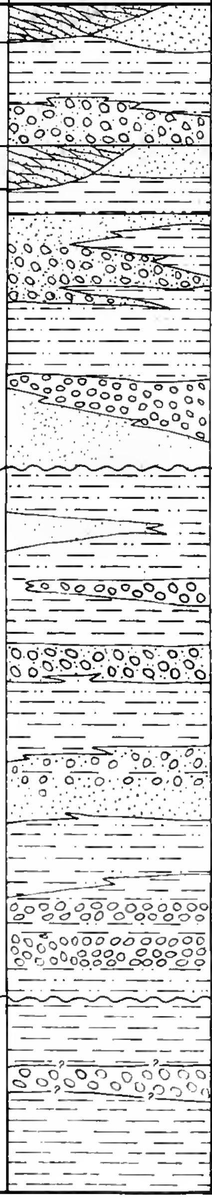
SILTY OR SANDY CLAY

CLAY OR SHALE

✸ DESIGNATIONS AND TERMS UTILIZED IN "REPORT OF REFEREE" DATED JUNE 1952 PREPARED BY THE STATE ENGINEER COVERING THE WEST COAST BASIN

† DESIGNATED AS "WATER BEARING ZONES" IN ABOVE NOTED REPORT OF REFEREE

IGRAPHIC COLUMN
)S ANGELES COUNTY

SYSTEM	SERIES	FORMATION	LITHOLOGY	AQUIFER AND AQUICLUDE	MAX THICKNESS (FEET)	PREVIOUS FORMATION NAMES✸	PREVIOUS AQUIFER NAMES✸
QUATERNARY	RECENT	ACTIVE DUNE SAND		SEMIPERCHED	60	ALLUVIUM	SEMIPERCHED†
		ALLUVIUM		BELLFLOWER AQUICLUDE	140		
				GASPUR	120		GASPUR†
				BALLONA	40		"50 FOOT GRAVEL"
	UPPER PLEISTOCENE	OLDER DUNE SAND		SEMIPERCHED		TERRACE COVER	
		LAKEWOOD FORMATION		BELLFLOWER AQUICLUDE	200	PALOS VERDES SAND	SEMIPERCHED†
				EXPOSITION ARTESIA	140	UNNAMED UPPER PLEISTOCENE	
				GARDENA	160		GARDENA†
				GAGE	160		"200 FOOT SAND"
		UNCONFORMITY				LOCAL UNCONFORMITY	
	LOWER PLEISTOCENE	SAN PEDRO FORMATION		HOLLYDALE	100	SAN PEDRO FORMATION	
				JEFFERSON	140		
				LYNWOOD	200		"400 FOOT GRAVEL"†
				SILVERADO	500		SILVERADO†
				SUNNYSIDE	500		
		LOCAL		UNCONFORMITY			
TERTIARY	UPPER PLIOCENE	PICO FORMATION		UNDIFFERENTIATED		PICO FORMATION	

LEGEND OF LITHOLOGY

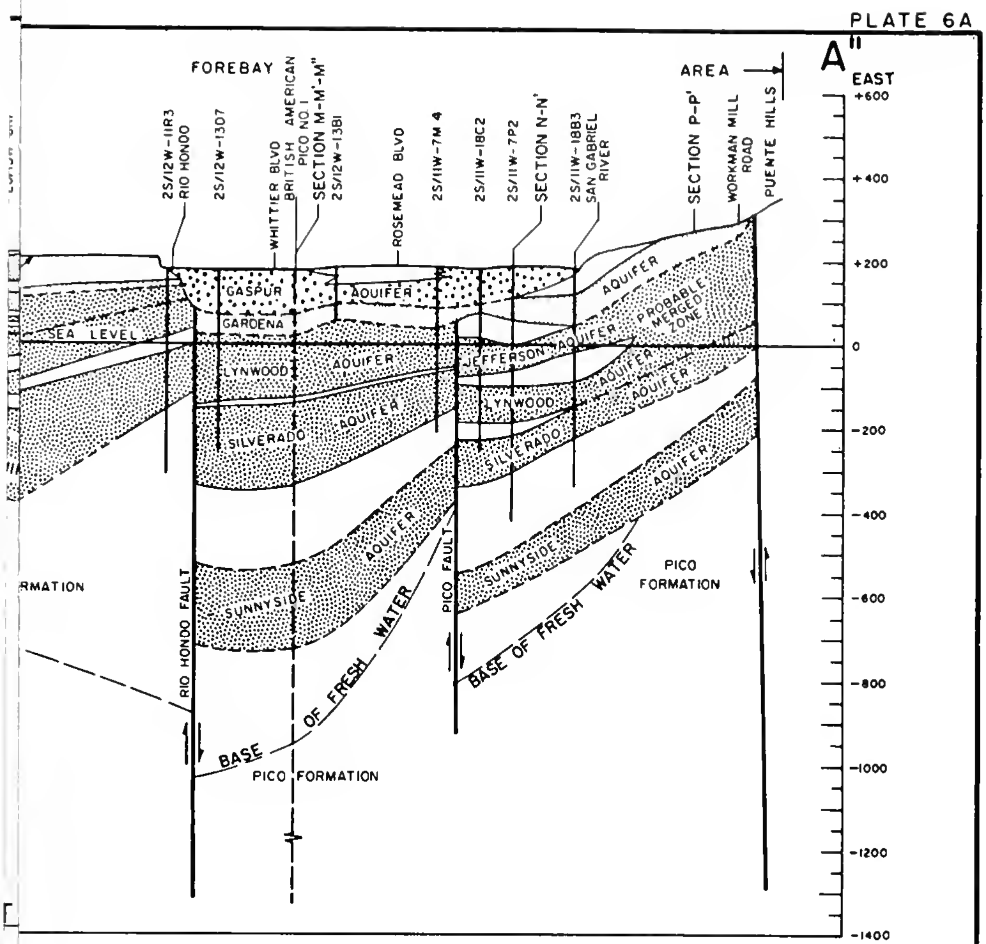
- GRAVEL AND SAND
- SAND
- SILTY OR SANDY CLAY
- CLAY OR SHALE

✸ DESIGNATIONS AND TERMS UTILIZED IN "REPORT OF REFEREE" DATED JUNE 1952 PREPARED BY THE STATE ENGINEER COVERING THE WEST COAST BASIN

† DESIGNATED AS "WATER BEARING ZONES" IN ABOVE NOTED REPORT OF REFEREE

GENERALIZED STRATIGRAPHIC COLUMN
COASTAL PLAIN OF LOS ANGELES COUNTY

DEPARTMENT OF WATER RESOURCES 1961



LEGEND

AQUICLUDES AND DEEPER UNDIFFERENTIATED FORMATIONS

AQUIFERS IN RECENT ALLUVIUM (INCLUDES THE GASPUR AND BALLONA AQUIFERS)

AQUIFERS IN LAKEWOOD FORMATION (INCLUDES THE ARTESIA, EXPOSITION, GAGE, AND GARDENA AQUIFERS)

AQUIFERS IN SAN PEDRO FORMATION (INCLUDES THE HOLLYDALE, JEFFERSON, LYNWOOD, SILVERADO, AND SUNNYSIDE AQUIFERS)

WATER WELLS

OIL WELLS

FAULTS

✳ BOUNDARY BETWEEN FOREBAY AND PRESSURE AREA AS SHOWN ON PLATE 2 OF THIS REPORT

NOTE: LOCATIONS OF GEOLOGIC SECTIONS ARE SHOWN ON PLATE 3A AND 3B

STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN CALIFORNIA DISTRICT

GROUND WATER GEOLOGY OF THE COASTAL PLAIN OF LOS ANGELES COUNTY

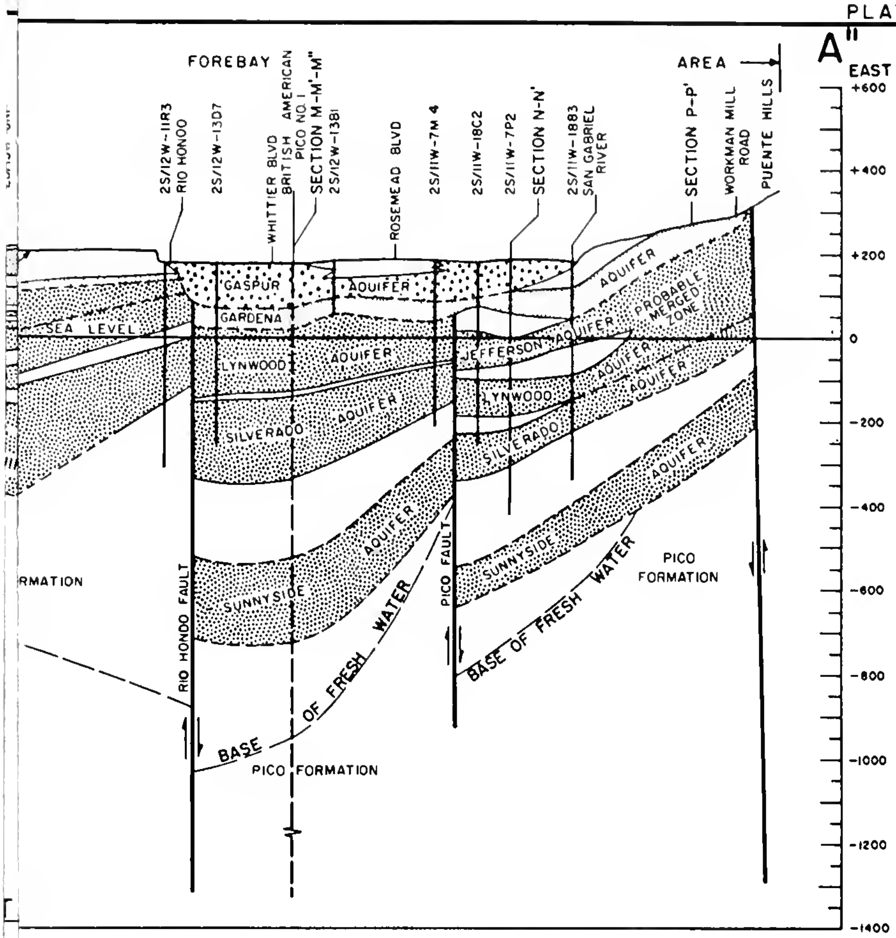
IDEALIZED GEOLOGIC SECTIONS A-A'-A" AND B-B'

HORIZONTAL SCALE OF FEET

2000 0 2000 4000 6000

1961

PLATE 6A



LEGEND

- AQUICLUDES AND DEEPER UNDIFFERENTIATED FORMATIONS
- AQUIFERS IN RECENT ALLUVIUM (INCLUDES THE GASPUR AND BALLONA AQUIFERS)
- AQUIFERS IN LAKEWOOD FORMATION (INCLUDES THE ARTESIA, EXPOSITION, GAGE, AND GARDENA AQUIFERS)
- AQUIFERS IN SAN PEDRO FORMATION (INCLUDES THE HOLLYDALE, JEFFERSON, LYNWOOD, SILVERADO, AND SUNNYSIDE AQUIFERS)
- WATER WELLS
- OIL WELLS
- FAULTS

✳ BOUNDARY BETWEEN FOREBAY AND PRESSURE AREA AS SHOWN ON PLATE 2 OF THIS REPORT

NOTE: LOCATIONS OF GEOLOGIC SECTIONS ARE SHOWN ON PLATE 3A AND 3B

STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN CALIFORNIA DISTRICT

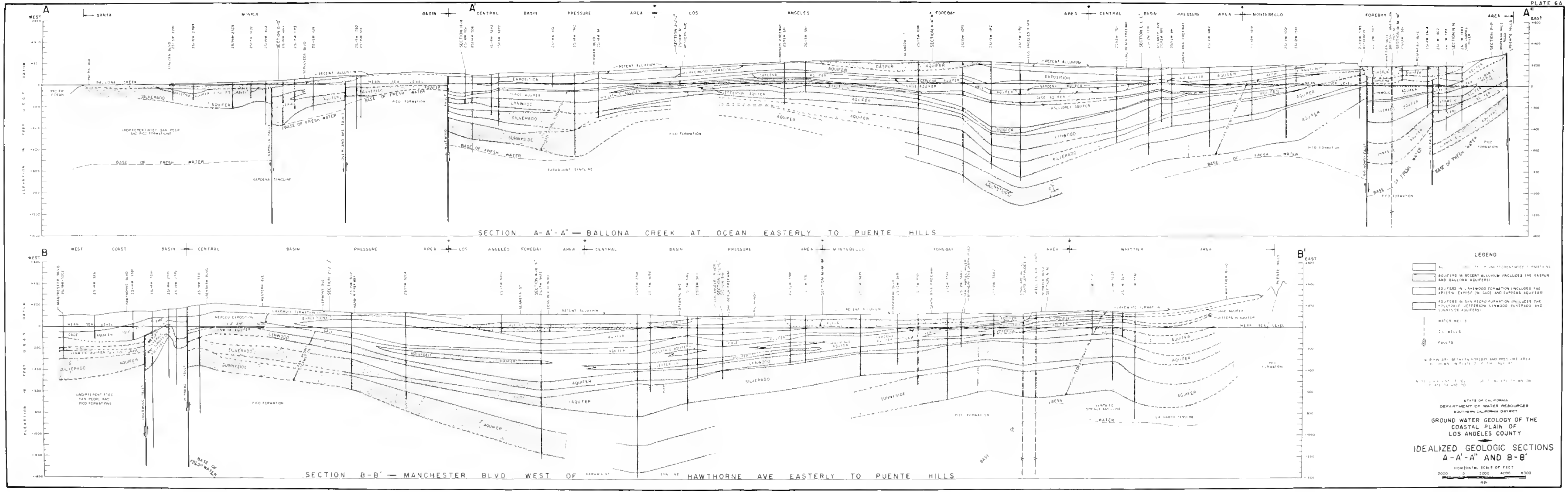
GROUND WATER GEOLOGY OF THE COASTAL PLAIN OF LOS ANGELES COUNTY

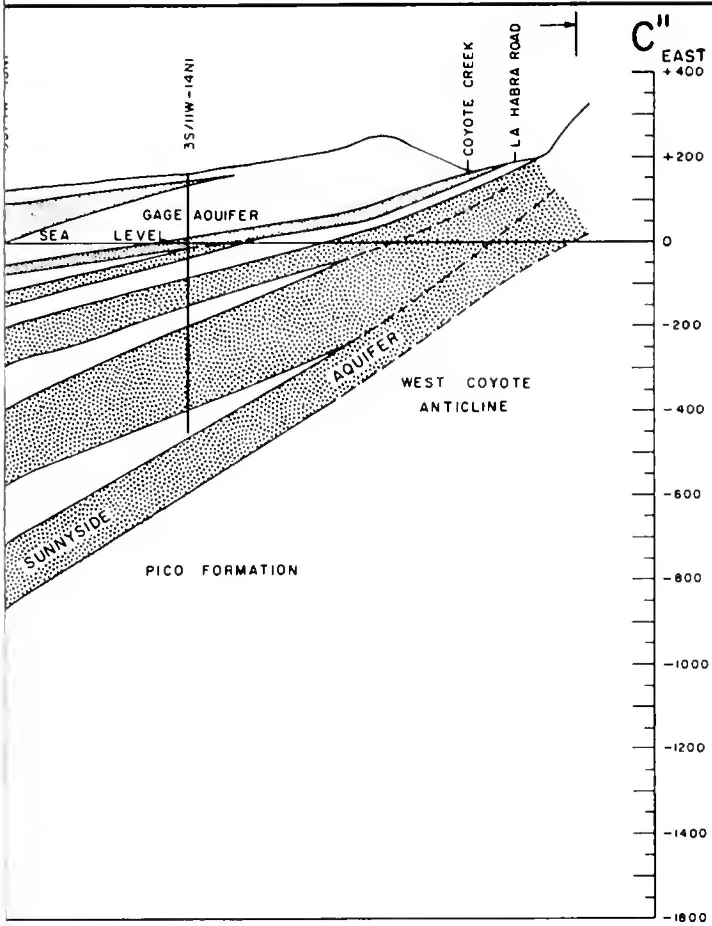
IDEALIZED GEOLOGIC SECTIONS A-A'-A" AND B-B'

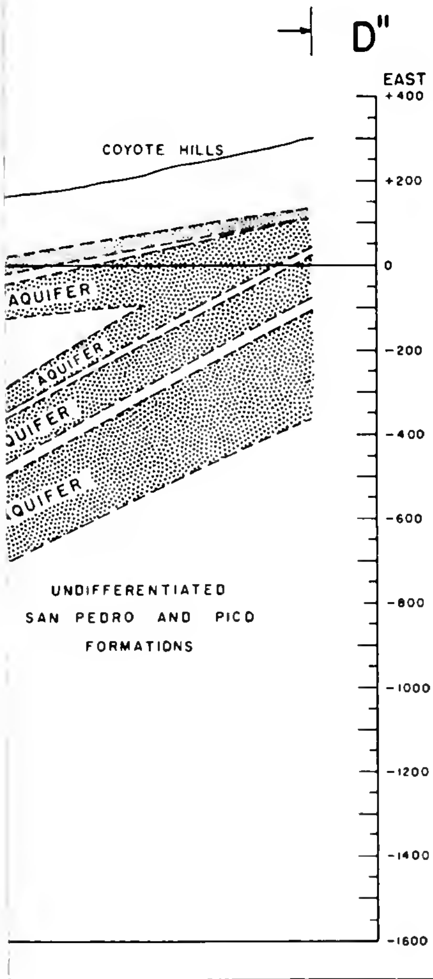
HORIZONTAL SCALE OF FEET

2000 0 2000 4000 6000

1961


SECTION A-A'-A" — BALLONA CREEK AT OCEAN EASTERLY TO PUENTE HILLS
SECTION B-B' — MANCHESTER BLVD WEST OF HAWTHORNE AVE EASTERLY TO PUENTE HILLS
LEGEND
AQUIFERS IN RECENT ALLUVIUM (INCLUDES THE GASPUR AND BALLONA AQUIFERS)
WATER WELLS
FAULTS
STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN CALIFORNIA DISTRICT
GROUND WATER GEOLOGY OF THE
COASTAL PLAIN OF
LOS ANGELES COUNTY
IDEALIZED GEOLOGIC SECTIONS
A-A'-A" AND B-B'
HORIZONTAL SCALE OF FEET
2000 0 2000 4000 6000





LEGEND

- AQUICLUDES AND DEEPER UNDIFFERENTIATED FORMATIONS
- AQUIFERS IN RECENT ALLUVIUM (INCLUDES THE GASPUR AND BALLONA AQUIFERS)
- AQUIFERS IN LAKEWOOD FORMATION (INCLUDES THE ARTESIA, EXPOSITION, GAGE, AND GARDENA AQUIFERS)
- AQUIFERS IN SAN PEDRO FORMATION (INCLUDES THE HOLLYDALE, JEFFERSON, LYNWOOD, SILVERADO, AND SUNNYSIDE AQUIFERS)
- WATER WELLS
- OIL WELLS
- FAULTS

NOTE: LOCATIONS OF GEOLOGIC SECTIONS ARE SHOWN ON PLATE 3A AND 3B

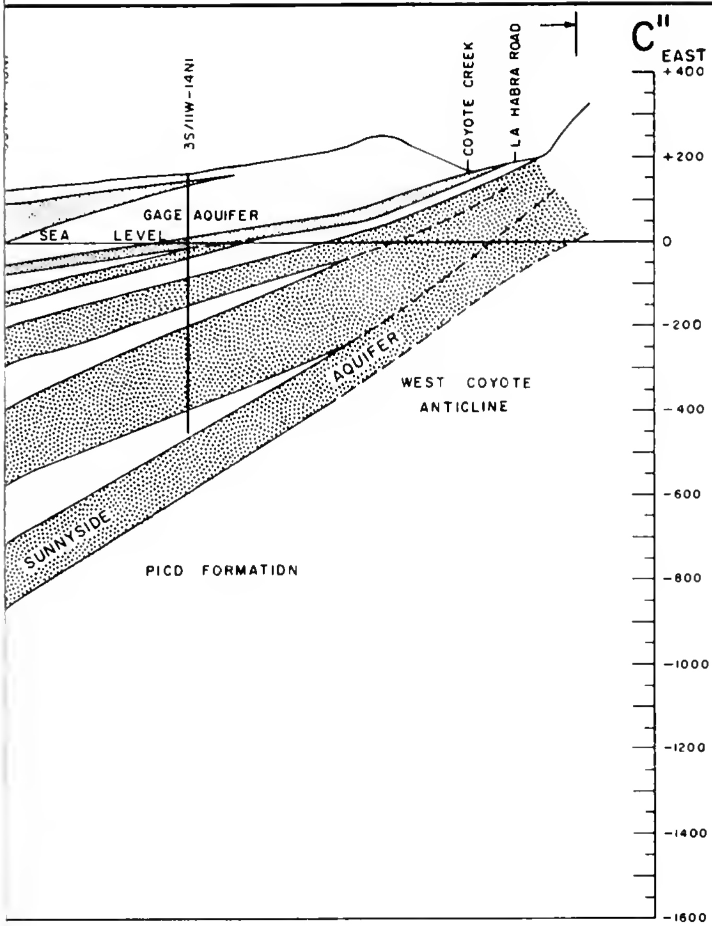
STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN CALIFORNIA DISTRICT

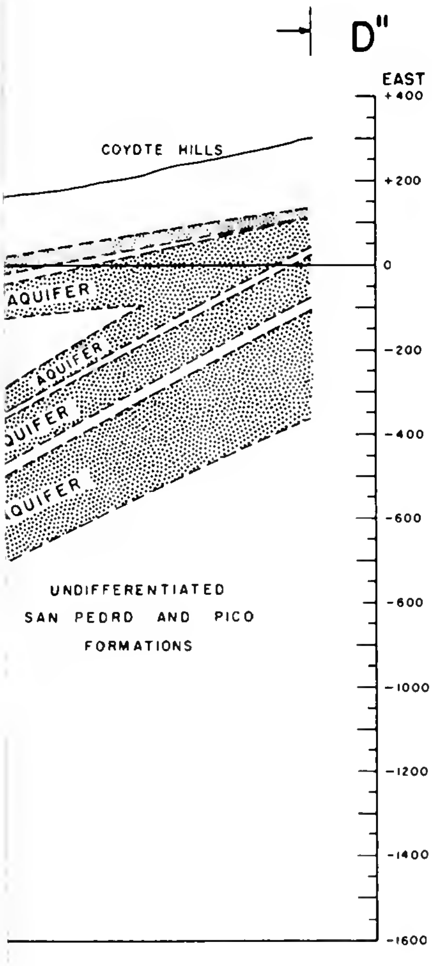
GROUND WATER GEOLOGY OF THE COASTAL PLAIN OF LOS ANGELES COUNTY

IDEALIZED GEOLOGIC SECTIONS C-C'-C" AND D-D'-D"

HORIZONTAL SCALE OF FEET
2000 0 2000 4000 6000

1961





LEGEND

- AQUICLUDES AND DEEPER UNDIFFERENTIATED FORMATIONS
- AQUIFERS IN RECENT ALLUVIUM (INCLUDES THE GASPUR AND BALLONA AQUIFERS)
- AQUIFERS IN LAKEWOOD FORMATION (INCLUDES THE ARTESIA, EXPOSITION, GAGE, AND GARDENA AQUIFERS)
- AQUIFERS IN SAN PEDRO FORMATION (INCLUDES THE HOLLYDALE, JEFFERSON, LYNWOOD, SILVERADO, AND SUNNYSIDE AQUIFERS)
- WATER WELLS
- OIL WELLS
- FAULTS

NOTE: LOCATIONS OF GEOLOGIC SECTIONS ARE SHOWN ON PLATE 3A AND 3B

STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN CALIFORNIA DISTRICT

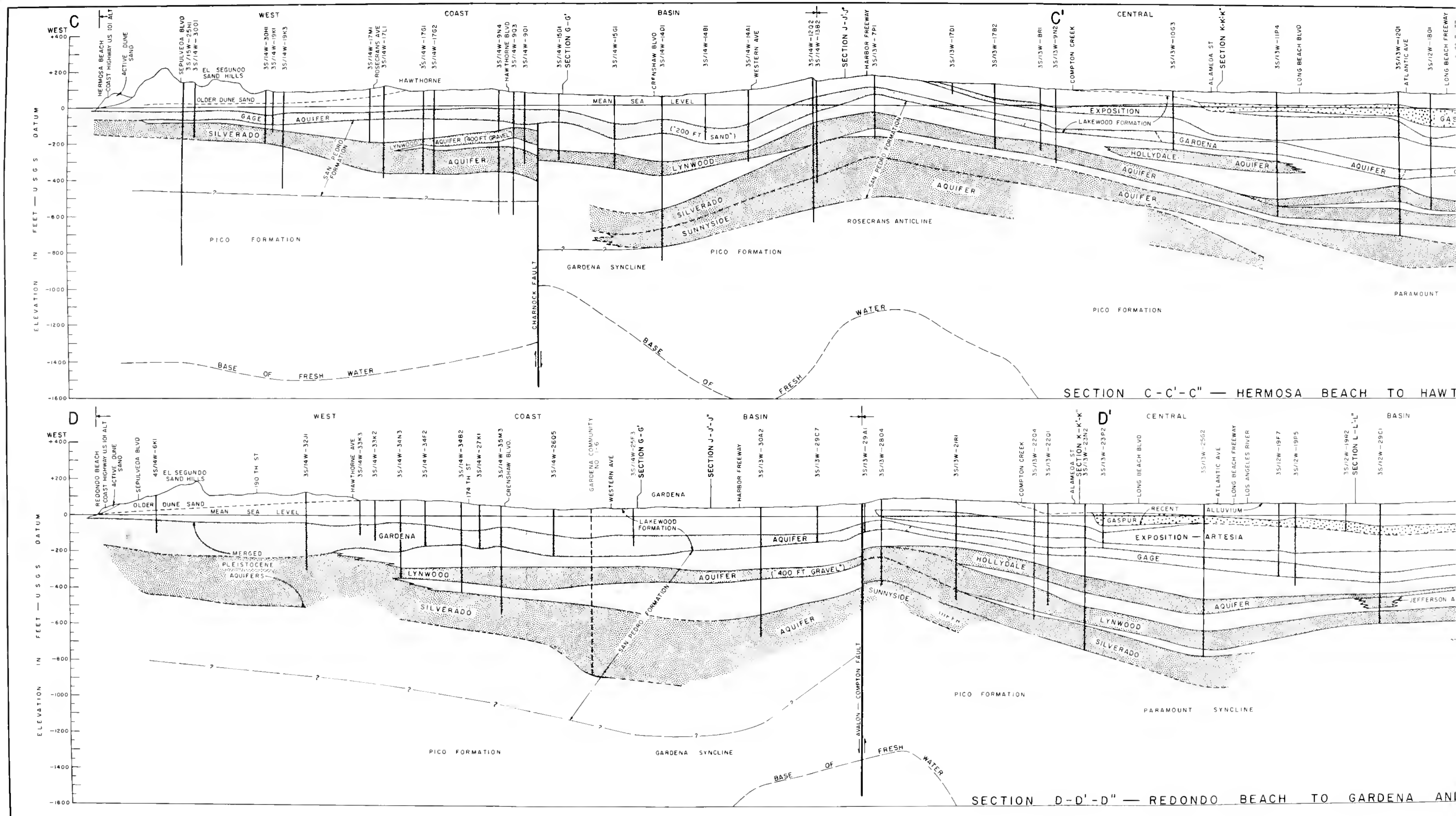
GROUND WATER GEOLOGY OF THE COASTAL PLAIN OF LOS ANGELES COUNTY

IDEALIZED GEOLOGIC SECTIONS C-C'-C'' AND D-D'-D''

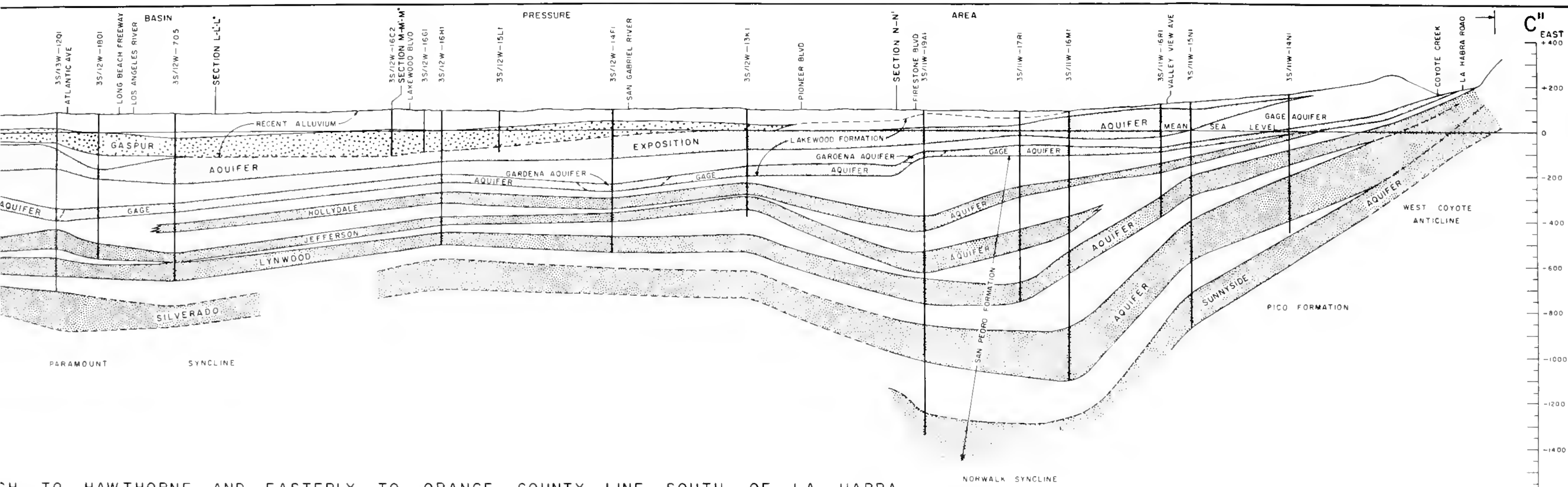
HORIZONTAL SCALE OF FEET

2000 0 2000 4000 6000

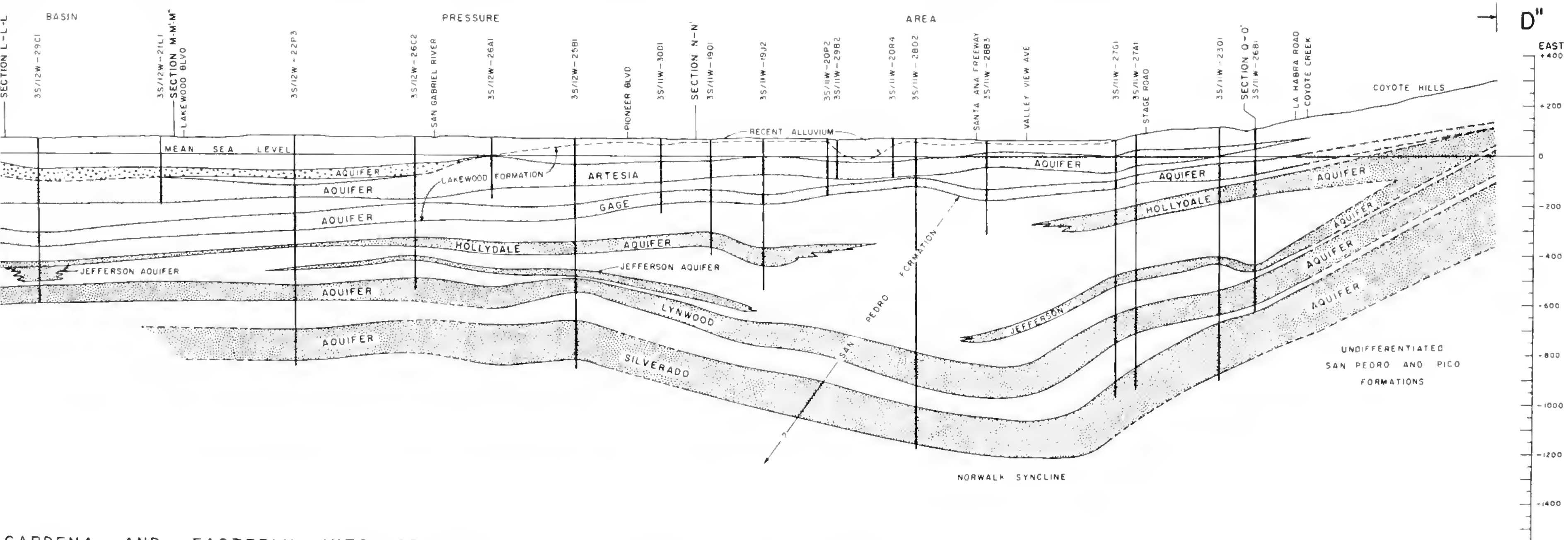
1961



C
C'
WEST
COAST
BASIN
CENTRAL
HERMOSA BEACH
COAST HIGHWAY US 101 ALT
ACTIVE DUNE SAND
SEPULVEDA BLVD
EL SEGUNDO SAND HILLS
OLDER DUNE SAND
HAWTHORNE
ROSECRANS AVE
HAWTHORNE BLVD
SECTION G-G'
CRENSHAW BLVD
WESTERN AVE
SECTION J-J'-J"
HARBOR FREEWAY
COMPTON CREEK
ALAMEDA ST
SECTION K-K'-K"
LONG BEACH BLVD
ATLANTIC AVE
MEAN SEA LEVEL
GAGE AQUIFER
SILVERADO
LYNWOOD AQUIFER (400 FT GRAVEL)
AQUIFER
("200 FT SAND")
LYNWOOD
SAN PEDRO FORMATION
EXPOSITION
LAKEWOOD FORMATION
GARDENA
HOLLYDALE
AQUIFER
SUNNYSIDE
ROSECRANS ANTICLINE
PICO FORMATION
GARDENA SYNCLINE
CHARNOCK FAULT
PARAMOUNT
BASE OF FRESH WATER
ELEVATION IN FEET — USGS DATUM
+400
+200
0
-200
-400
-600
-800
-1000
-1200
-1400
-1600
SECTION C-C'-C" — HERMOSA BEACH TO HAWT
D
D'
REDONDO BEACH
COAST HIGHWAY U.S. 101 ALT
190 TH ST
HAWTHORNE AVE
174 TH ST
CRENSHAW BLVD.
GARDENA COMMUNITY NO 1-6
WESTERN AVE
SECTION G-G'
GARDENA
SECTION J-J'-J"
HARBOR FREEWAY
COMPTON CREEK
ALAMEDA ST
SECTION K-K'-K"
LONG BEACH BLVD
ATLANTIC AVE
LONG BEACH FREEWAY
LOS ANGELES RIVER
SECTION L-L'-L"
MERGED PLEISTOCENE AQUIFERS
LAKEWOOD FORMATION
RECENT
GASPUR
ALLUVIUM
EXPOSITION — ARTESIA
GAGE
HOLLYDALE
SUNNYSIDE
JEFFERSON A
AVALON — COMPTON FAULT
PARAMOUNT SYNCLINE
SECTION D-D'-D" — REDONDO BEACH TO GARDENA AN



CH TO HAWTHORNE AND EASTERLY TO ORANGE COUNTY LINE SOUTH OF LA HABRA



GARDENA AND EASTERLY INTO ORANGE COUNTY NORTH OF BUENA PARK

LEGEND

- AQUICLUDES AND DEEPER UNDIFFERENTIATED FORMATIONS
- AQUIFERS IN RECENT ALLUVIUM (INCLUDES THE GASPUR AND BALLONA AQUIFERS)
- AQUIFERS IN LAKEWOOD FORMATION (INCLUDES THE ARTESIA, EXPOSITION, GAGE, AND GARDENA AQUIFERS)
- AQUIFERS IN SAN PEDRO FORMATION (INCLUDES THE HOLLYDALE, JEFFERSON, LYNWOOD, SILVERADO, AND SUNNYSIDE AQUIFERS)
- WATER WELLS
- OIL WELLS
- FAULTS

NOTE: LOCATIONS OF GEOLOGIC SECTIONS ARE SHOWN ON PLATE 3A AND 3B

STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN CALIFORNIA DISTRICT

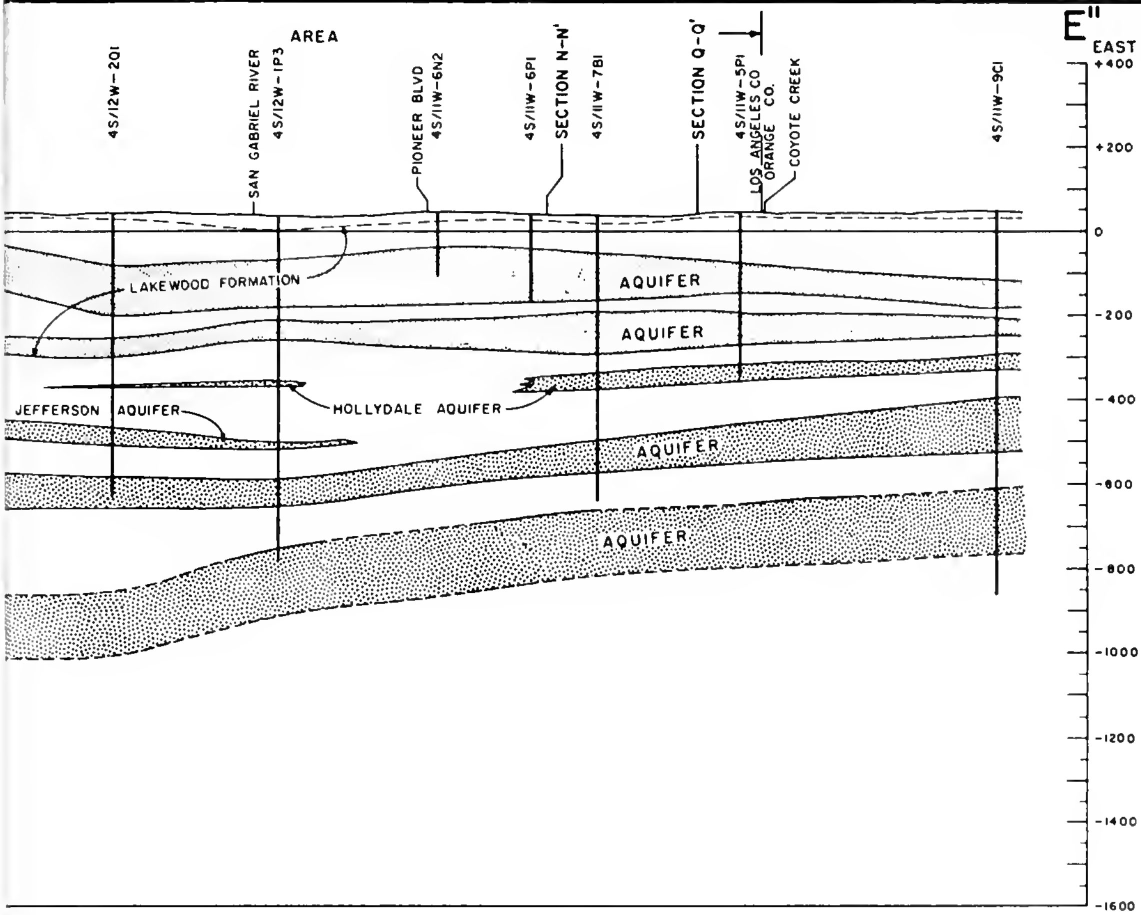
GROUND WATER GEOLOGY OF THE COASTAL PLAIN OF LOS ANGELES COUNTY

IDEALIZED GEOLOGIC SECTIONS C-C'-C" AND D-D'-D"

HORIZONTAL SCALE OF FEET

2000 0 2000 4000 6000

1961



LEGEND

AQUICLUDES AND DEEPER UNDIFFERENTIATED FORMATIONS

AQUIFERS IN RECENT ALLUVIUM (INCLUDES THE GASPUR AND BALLONA AQUIFERS)

AQUIFERS IN LAKEWOOD FORMATION (INCLUDES THE ARTESIA, EXPOSITION, GAGE, AND GARDENA AQUIFERS)

AQUIFERS IN SAN PEDRO FORMATION (INCLUDES THE HOLLYDALE, JEFFERSON, LYNWOOD, SILVERADO, AND SUNNYSIDE AQUIFERS)

WATER WELLS

OIL WELLS

FAULTS

NOTE: LOCATIONS OF GEOLOGIC SECTIONS ARE SHOWN ON PLATE 3A AND 3B

STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN CALIFORNIA DISTRICT

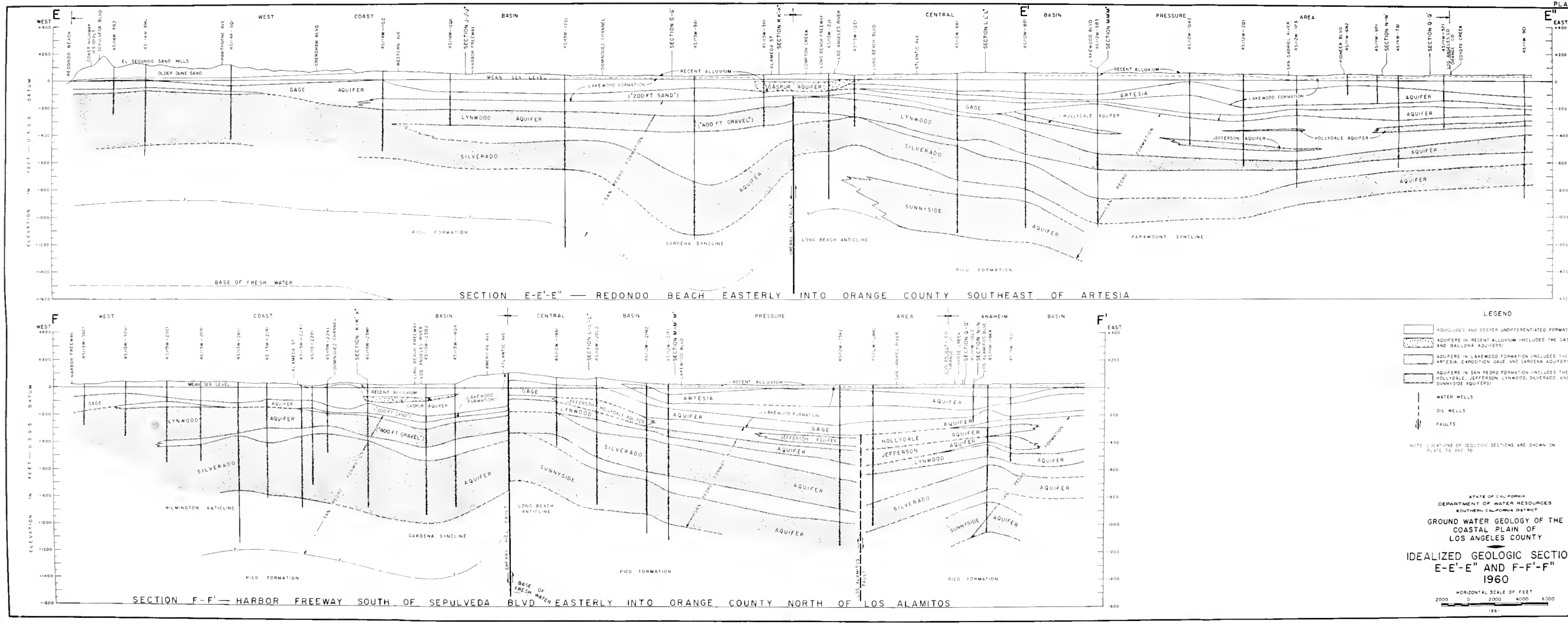
GROUND WATER GEOLOGY OF THE COASTAL PLAIN OF LOS ANGELES COUNTY

IDEALIZED GEOLOGIC SECTIONS E-E'-E" AND F-F'-F" 1960

HORIZONTAL SCALE OF FEET

2000 0 2000 4000 6000

1961



LEGEND

AQUICLUDES AND DEEPER UNDIFFERENTIATED FORMATIONS

AQUIFERS IN RECENT ALLUVIUM (INCLUDES THE GASPUR AND BALLONA AQUIFERS)

AQUIFERS IN LAKEWOOD FORMATION (INCLUDES THE ARTESIA, EXPOSITION GAGE AND GARDENA AQUIFERS

AQUIFERS IN SAN PEDRO FORMATION (INCLUDES THE HOLLYDALE, JEFFERSON LYNWOOD, SILVERADO AND SUNNYSIDE AQUIFERS)

WATER WELLS

OIL WELLS

FAULTS

NOTE LOCATIONS OF GEOLOGIC SECTIONS ARE SHOWN ON PLATE 3A AND 3B

STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN CALIFORNIA DISTRICT

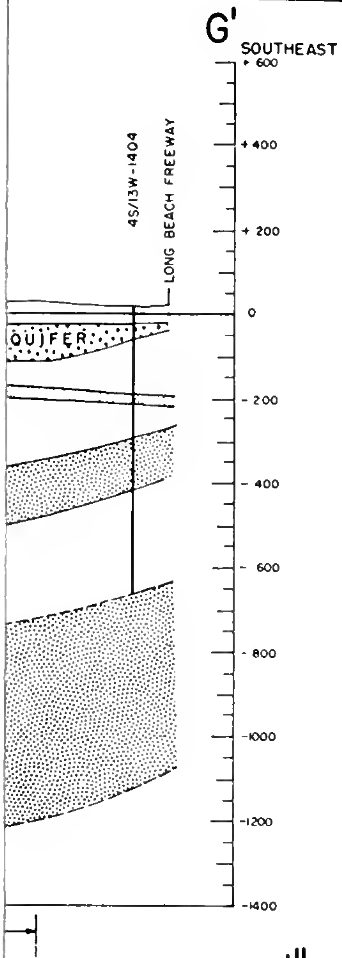
GROUND WATER GEOLOGY OF THE COASTAL PLAIN OF LOS ANGELES COUNTY

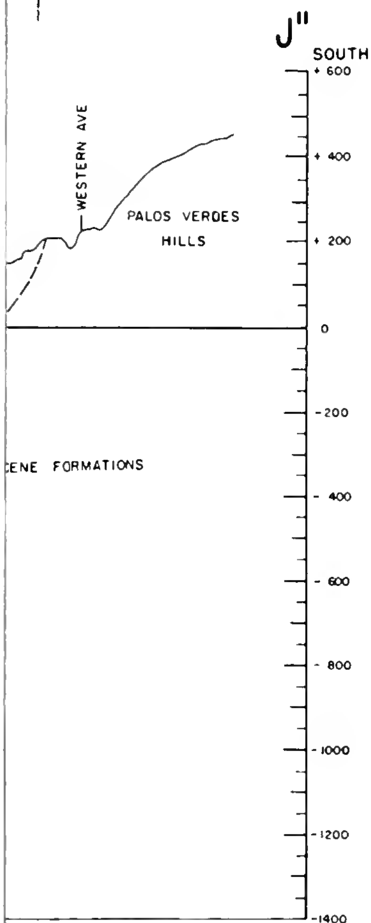
IDEALIZED GEOLOGIC SECTIONS E-E'-E" AND F-F'-F" 1960

HORIZONTAL SCALE OF FEET

2000 0 2000 4000 6000

1961





LEGEND

AQUICLUDES AND DEEPER UNDIFFERENTIATED FORMATIONS

AQUIFERS IN RECENT ALLUVIUM (INCLUDES THE GASPUR AND BALLONA AQUIFERS)

AQUIFERS IN LAKEWOOD FORMATION (INCLUDES THE ARTESIA, EXPOSITION, GAGE, AND GARDENA AQUIFERS)

AQUIFERS IN SAN PEDRO FORMATION (INCLUDES THE HOLLYDALE, JEFFERSON, LYNWOOD, SILVERADO, AND SUNNYSIDE AQUIFERS)

WATER WELLS

OIL WELLS

FAULTS

✳ BOUNDARY BETWEEN FOREBAY AND PRESSURE AREA AS SHOWN ON PLATE 2 OF THIS REPORT

NOTE. LOCATIONS OF GEOLOGIC SECTIONS ARE SHOWN ON PLATE 3A AND 3B

STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN CALIFORNIA DISTRICT

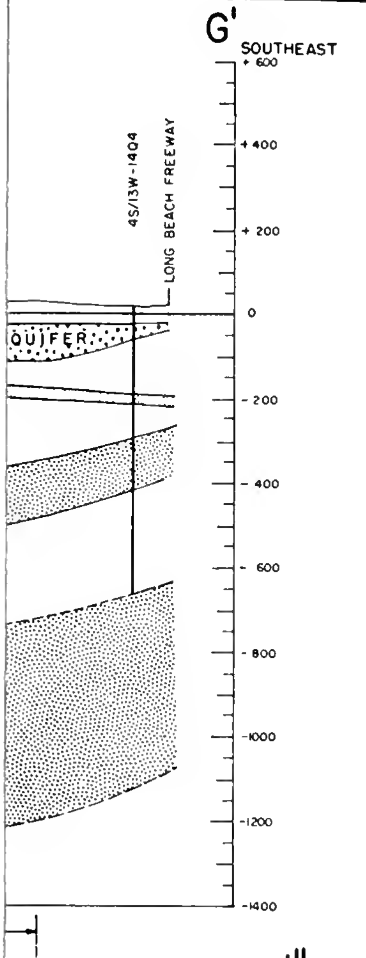
GROUND WATER GEOLOGY OF THE COASTAL PLAIN OF LOS ANGELES COUNTY

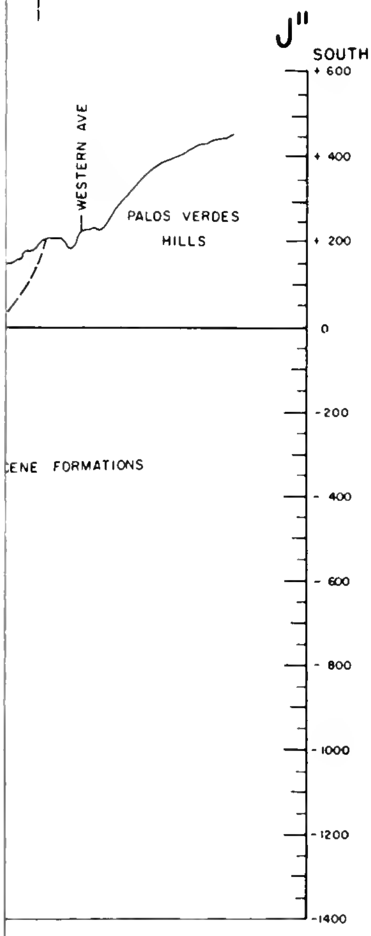
IDEALIZED GEOLOGIC SECTIONS G-G' AND J-J'-J''

HORIZONTAL SCALE OF FEET

2000 0 2000 4000 6000

1961





LEGEND

- AQUICLUDES AND DEEPER UNDIFFERENTIATED FORMATIONS
- AQUIFERS IN RECENT ALLUVIUM (INCLUDES THE GASPUR AND BALLONA AQUIFERS)
- AQUIFERS IN LAKEWOOD FORMATION (INCLUDES THE ARTESIA, EXPOSITION, GAGE, AND GARDENA AQUIFERS)
- AQUIFERS IN SAN PEDRO FORMATION (INCLUDES THE HOLLYDALE, JEFFERSON, LYNWOOD, SILVERADO, AND SUNNYSIDE AQUIFERS)
- WATER WELLS
- OIL WELLS
- FAULTS

* BOUNDARY BETWEEN FOREBAY AND PRESSURE AREA AS SHOWN ON PLATE 2 OF THIS REPORT

NOTE. LOCATIONS OF GEOLOGIC SECTIONS ARE SHOWN ON PLATE 3A AND 3B

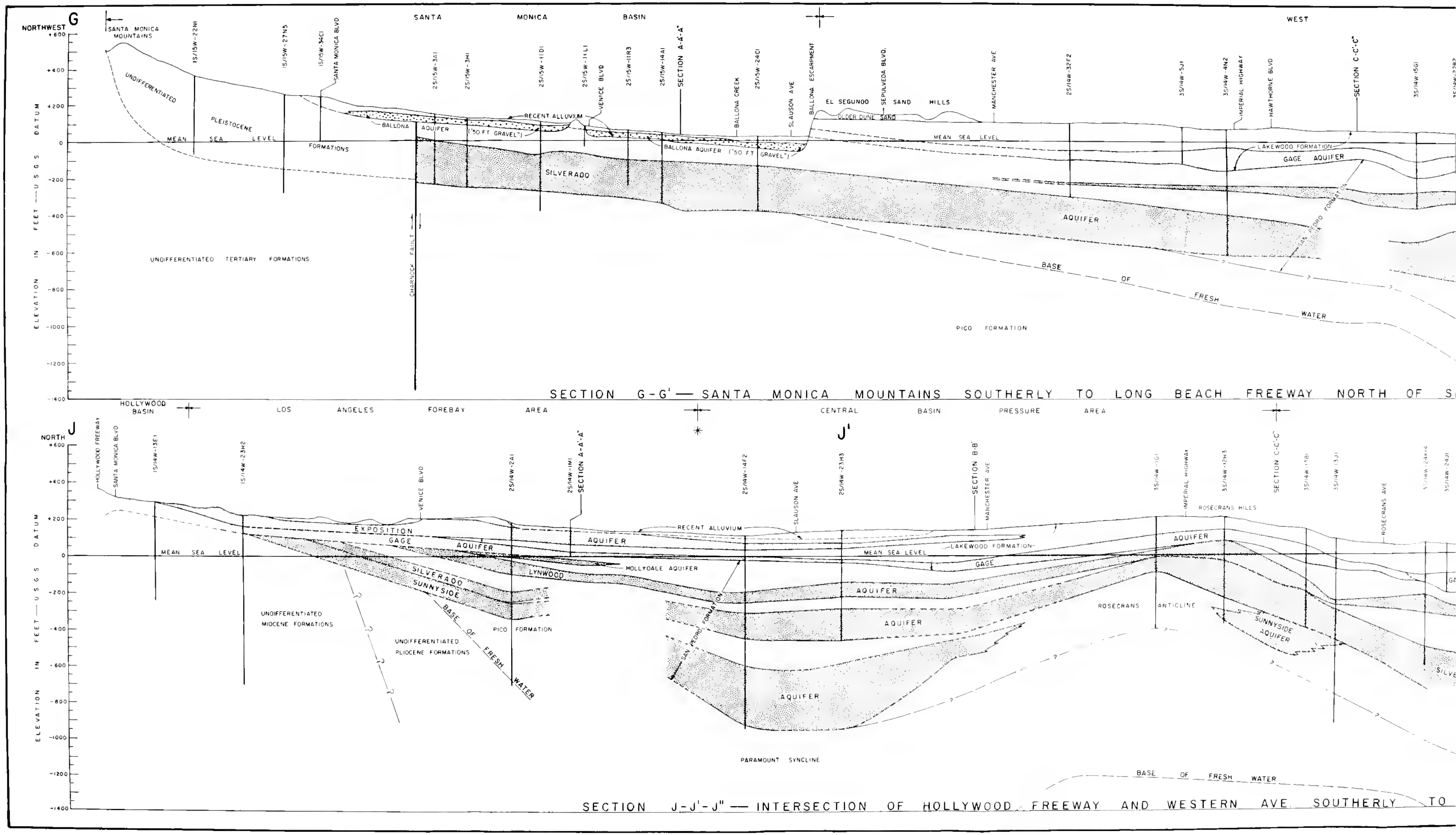
STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN CALIFORNIA DISTRICT

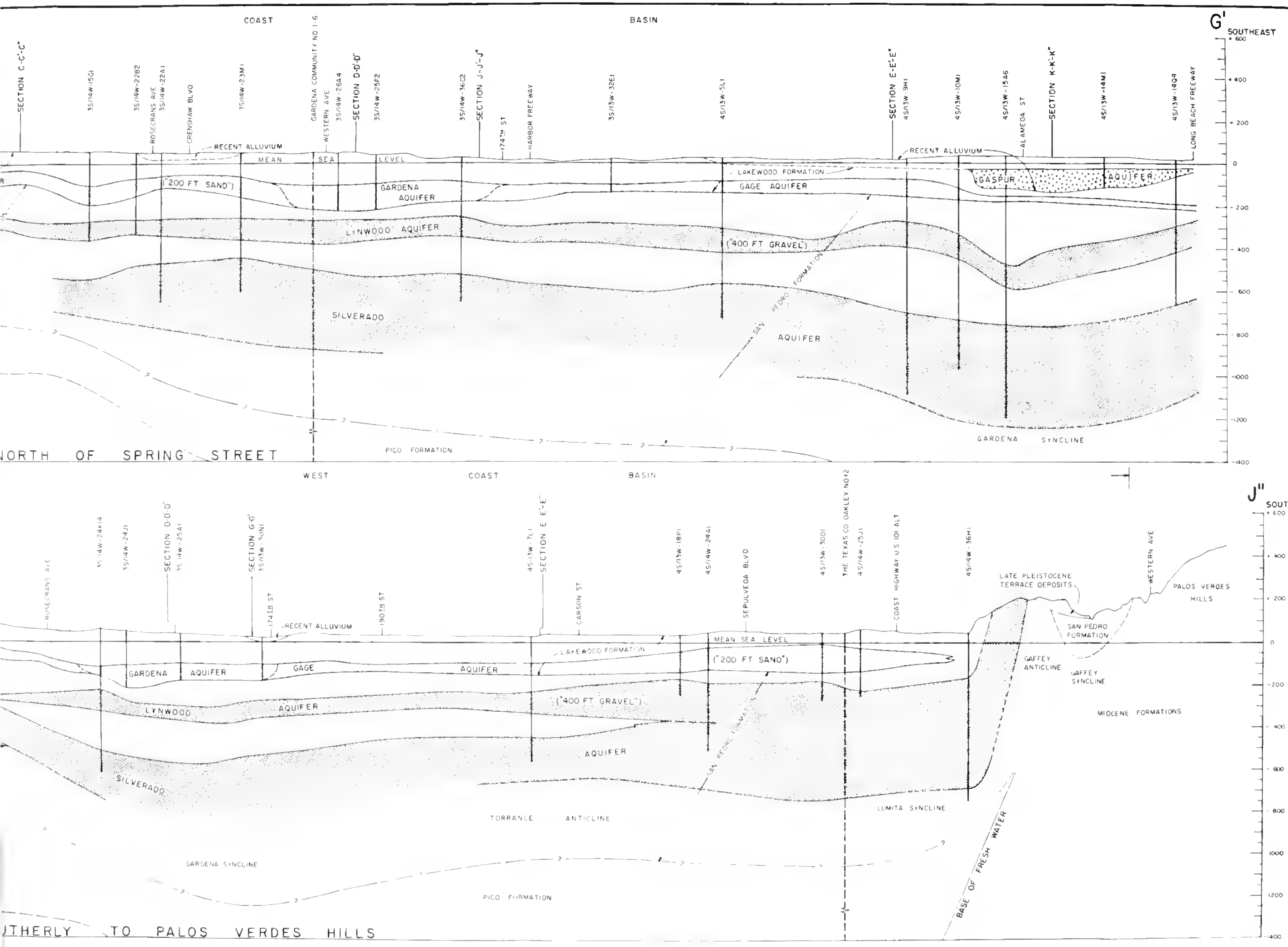
GROUND WATER GEOLOGY OF THE COASTAL PLAIN OF LOS ANGELES COUNTY

IDEALIZED GEOLOGIC SECTIONS G-G' AND J-J'-J''

HORIZONTAL SCALE OF FEET
2000 0 2000 4000 6000

1961


SECTION G-G' — SANTA MONICA MOUNTAINS SOUTHERLY TO LONG BEACH FREEWAY NORTH OF S
G
NORTHWEST
SANTA MONICA MOUNTAINS
SANTA MONICA BASIN
WEST
ELEVATION IN FEET — USGS DATUM
+600
+400
+200
0
-200
-400
-600
-800
-1000
-1200
-1400
1S/15W-22N1
1S/15W-27N5
1S/15W-34C1
SANTA MONICA BLVD
2S/15W-3A1
2S/15W-3H1
2S/15W-11D1
2S/15W-11L1
VENICE BLVD
2S/15W-11R3
2S/15W-14A1
SECTION A-A'-A"
BALLONA CREEK
2S/15W-24C1
SLAUSON AVE
BALLONA ESCARPMENT
SEPULVEDA BLVD.
MANCHESTER AVE
2S/14W-32F2
3S/14W-5J1
3S/14W-4N2
IMPERIAL HIGHWAY
HAWTHORNE BLVD
SECTION C-C'-C"
3S/14W-15G1
UNDIFFERENTIATED
PLEISTOCENE
FORMATIONS
MEAN SEA LEVEL
RECENT ALLUVIUM
BALLONA AQUIFER ("50 FT GRAVEL")
EL SEGUNDO SAND HILLS
OLDER DUNE SAND
LAKEWOOD FORMATION
GAGE AQUIFER
SILVERADO AQUIFER
SAN PEDRO FORMATION
CHARNOCK FAULT
UNDIFFERENTIATED TERTIARY FORMATIONS
BASE OF FRESH WATER
PICO FORMATION
SECTION J-J'-J" — INTERSECTION OF HOLLYWOOD FREEWAY AND WESTERN AVE. SOUTHERLY TO
J
J'
NORTH
HOLLYWOOD BASIN
LOS ANGELES FOREBAY AREA
CENTRAL BASIN PRESSURE AREA
HOLLYWOOD FREEWAY
SANTA MONICA BLVD
1S/14W-13E1
1S/14W-23H2
VENICE BLVD
2S/14W-2A1
2S/14W-1M1
SECTION A-A'-A"
2S/14W-14F2
SLAUSON AVE
2S/14W-23H3
SECTION B-B'
MANCHESTER AVE
3S/14W-1G1
IMPERIAL HIGHWAY
3S/14W-12H3
SECTION C-C'-C"
ROSECRANS HILLS
ROSECRANS AVE
EXPOSITION AQUIFER
GAGE AQUIFER
RECENT ALLUVIUM
LAKEWOOD FORMATION
MEAN SEA LEVEL
HOLLYDALE AQUIFER
LYNWOOD
SILVERADO
SUNNYSIDE
GAGE
AQUIFER
UNDIFFERENTIATED MIOCENE FORMATIONS
UNDIFFERENTIATED PLIOCENE FORMATIONS
PICO FORMATION
SAN PEDRO FORMATION
ROSECRANS ANTICLINE
SUNNYSIDE AQUIFER
PARAMOUNT SYNCLINE
BASE OF FRESH WATER



LEGEND

AQUICLUDES AND DEEPER UNDIFFERENTIATED FORMATIONS

AQUIFERS IN RECENT ALLUVIUM (INCLUDES THE GASPUR AND BALLONA AQUIFERS)

AQUIFERS IN LAKEWOOD FORMATION (INCLUDES THE ARTESIA, EXPOSITION, GAGE, AND GARDENA AQUIFERS)

AQUIFERS IN SAN PEDRO FORMATION (INCLUDES THE HOLLYDALE, JEFFERSON, LYNWOOD, SILVERADO, AND SUNNYSIDE AQUIFERS)

WATER WELLS

OIL WELLS

FAULTS

BOUNDARY BETWEEN FOREBAY AND PRESSURE AREA AS SHOWN ON PLATE 2 OF THIS REPORT

NOTE: LOCATIONS OF GEOLOGIC SECTIONS ARE SHOWN ON PLATE 3A AND 3B

STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN CALIFORNIA DISTRICT

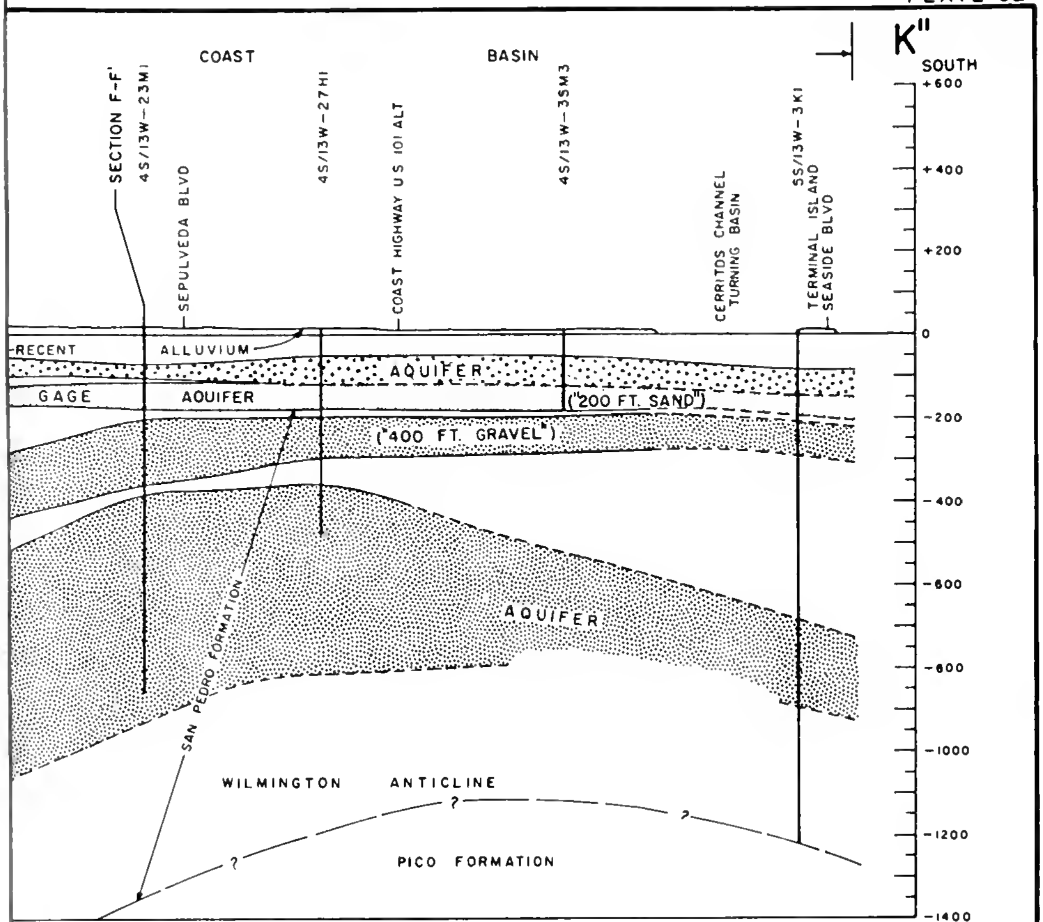
GROUND WATER GEOLOGY OF THE COASTAL PLAIN OF LOS ANGELES COUNTY

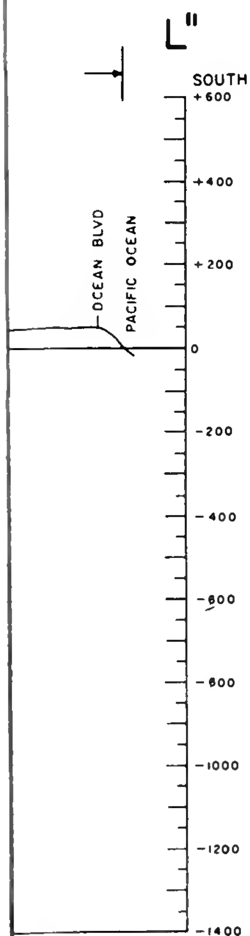
IDEALIZED GEOLOGIC SECTIONS G-G' AND J-J'-J"

HORIZONTAL SCALE OF FEET

2000 0 2000 4000 6000

1961





LEGEND

- AQUICLUDES AND DEEPER UNDIFFERENTIATED FORMATIONS
- AQUIFERS IN RECENT ALLUVIUM (INCLUDES THE BASPUR AND BALLONA AQUIFERS)
- AQUIFERS IN LAKEWOOD FORMATION (INCLUDES THE ARTESIA, EXPOSITION, GAGE, AND GARDENA AQUIFERS)
- AQUIFERS IN SAN PEDRO FORMATION (INCLUDES THE HOLLYDALE, JEFFERSON, LYNWOOD, SILVERADO, AND SUNNYSIDE AQUIFERS)
- WATER WELLS
- OIL WELLS
- FAULTS

✳ BOUNDARY BETWEEN FOREBAY AND PRESSURE AREA AS SHOWN ON PLATE 2 OF THIS REPORT

NOTE: LOCATIONS OF GEOLOGIC SECTIONS ARE SHOWN ON PLATE 3A AND 3B

STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN CALIFORNIA DISTRICT

GROUND WATER GEOLOGY OF THE COASTAL PLAIN OF LOS ANGELES COUNTY

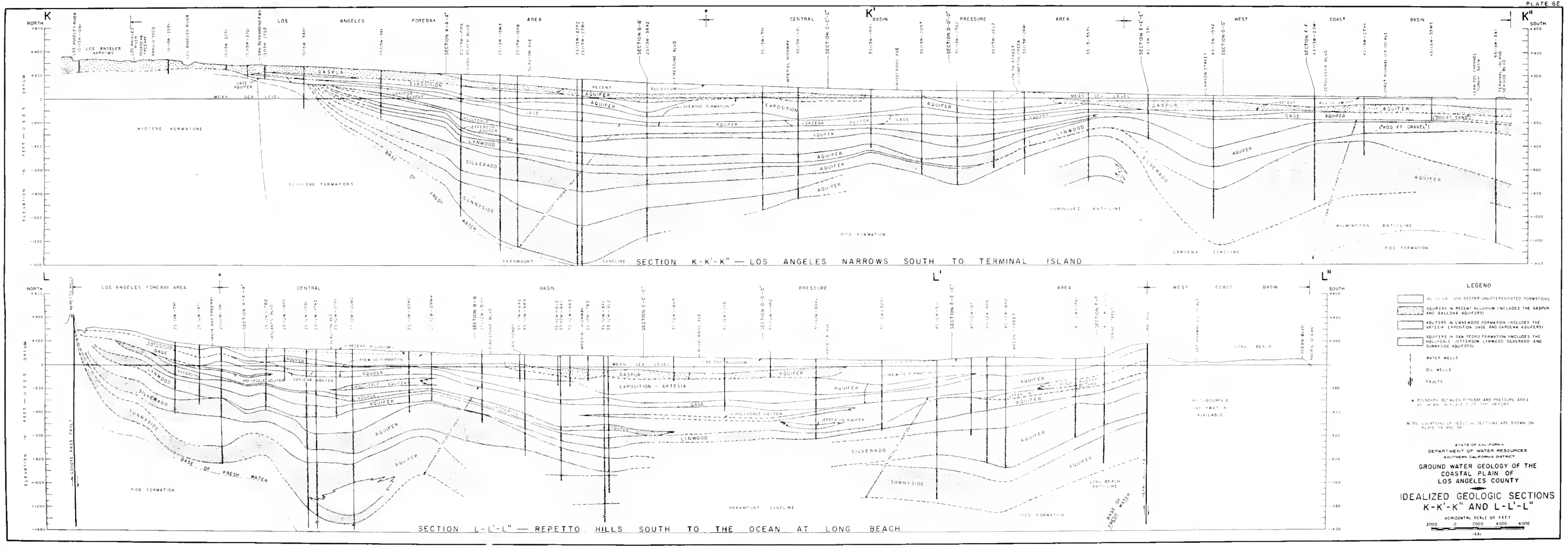
IDEALIZED GEOLOGIC SECTIONS K-K'-K" AND L-L'-L"

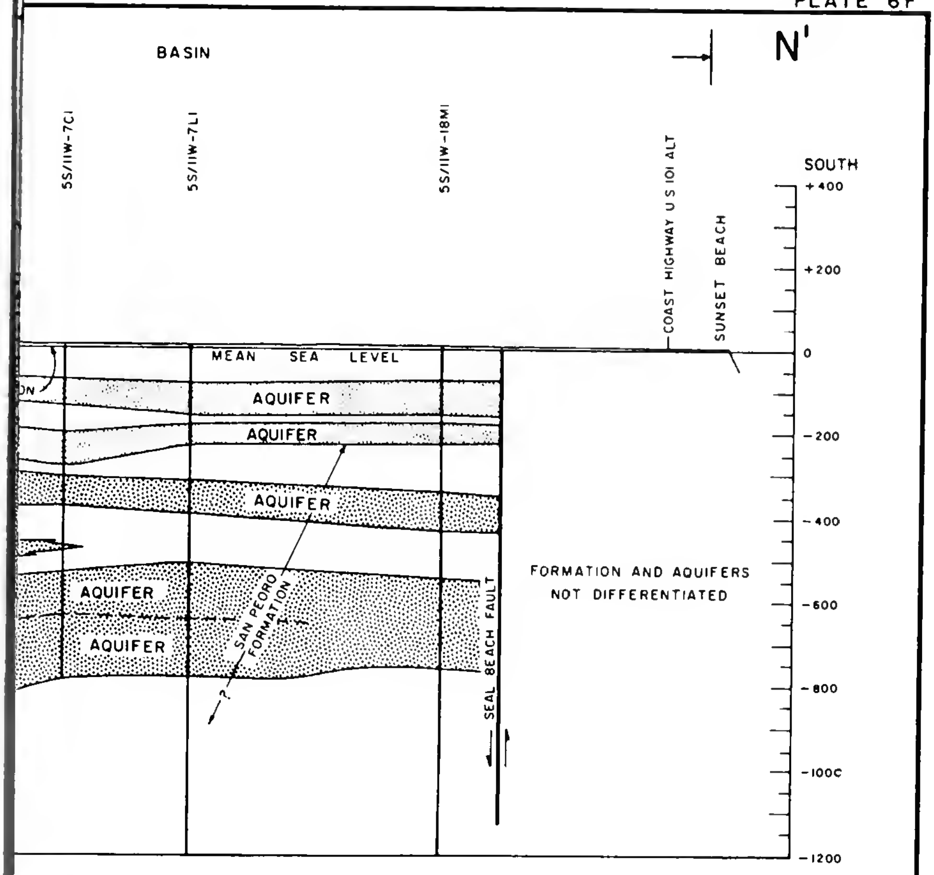
HORIZONTAL SCALE OF FEET

2000 0 2000 4000 6000

1961

PLATE 6E


SECTION K-K'-K" — LOS ANGELES NARROWS SOUTH TO TERMINAL ISLAND
LOS ANGELES FOREBAY AREA
CENTRAL BASIN PRESSURE AREA
WEST COAST BASIN
NORTH
SOUTH
ELEVATION IN FEET — U.S.G.S. DATUM
MEAN SEA LEVEL
GASPUR
EXPOSITION
GARDENA AQUIFER
GAGE AQUIFER
RECENT ALLUVIUM
LAKEWOOD FORMATION
HOLLYDALE
JEFFERSON AQUIFER
LYNWOOD
SILVERADO
SUNNYSIDE
AQUIFER
BASE OF FRESH WATER
MIOCENE FORMATIONS
PLIOCENE FORMATIONS
PICO FORMATION
DOMINGUEZ ANTICLINE
WILMINGTON ANTICLINE
GARDENA SYNCLINE
PARAMOUNT SYNCLINE
(200 FT SAND)
(400 FT GRAVEL)
SECTION L-L'-L" — REPETTO HILLS SOUTH TO THE OCEAN AT LONG BEACH
LOS ANGELES FOREBAY AREA
CENTRAL BASIN PRESSURE AREA
WEST COAST BASIN
COYOTE PASS FAULT
EXPOSITION - ARTESIA
HOLLYDALE AQUIFER
JEFFERSON AQUIFER
LONG BEACH ANTICLINE
PARAMOUNT SYNCLINE
PICO FORMATION
LONG BEACH
PACIFIC OCEAN
LEGEND
AGE IN DOUBT AND DEEPER UNDIFFERENTIATED FORMATIONS
AQUIFERS IN RECENT ALLUVIUM (INCLUDES THE GASPUR AND BALLONA AQUIFERS)
AQUIFERS IN LAKEWOOD FORMATION (INCLUDES THE ARTESIA, EXPOSITION, GAGE AND GARDENA AQUIFERS)
AQUIFERS IN SAN PEDRO FORMATION (INCLUDES THE HOLLYDALE, JEFFERSON, LYNWOOD, SILVERADO AND SUNNYSIDE AQUIFERS)
WATER WELLS
OIL WELLS
FAULTS
STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN CALIFORNIA DISTRICT
GROUND WATER GEOLOGY OF THE COASTAL PLAIN OF LOS ANGELES COUNTY
IDEALIZED GEOLOGIC SECTIONS K-K'-K" AND L-L'-L"
HORIZONTAL SCALE OF FEET
2000 0 2000 4000 6000
1961



TH

LEGEND

AQUICLUDES AND DEEPER UNDIFFERENTIATED FORMATIONS

AQUIFERS IN RECENT ALLUVIUM (INCLUDES THE GASPUR AND BALLONA AQUIFERS)

AQUIFERS IN LAKEWOOD FORMATION (INCLUDES THE ARTESIA, EXPOSITION, GAGE, AND GARDENA AQUIFERS)

AQUIFERS IN SAN PEDRO FORMATION (INCLUDES THE HOLLYDALE, JEFFERSON, LYNWOOD, SILVERADO, AND SUNNYSIDE AQUIFERS)

WATER WELLS

OIL WELLS

FAULTS

✳ BOUNDARY BETWEEN FOREBAY AND PRESSURE AREA AS SHOWN ON PLATE 2 OF THIS REPORT

NOTE: LOCATIONS OF GEOLOGIC SECTIONS ARE SHOWN ON PLATE 3A AND 3B

STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN CALIFORNIA DISTRICT

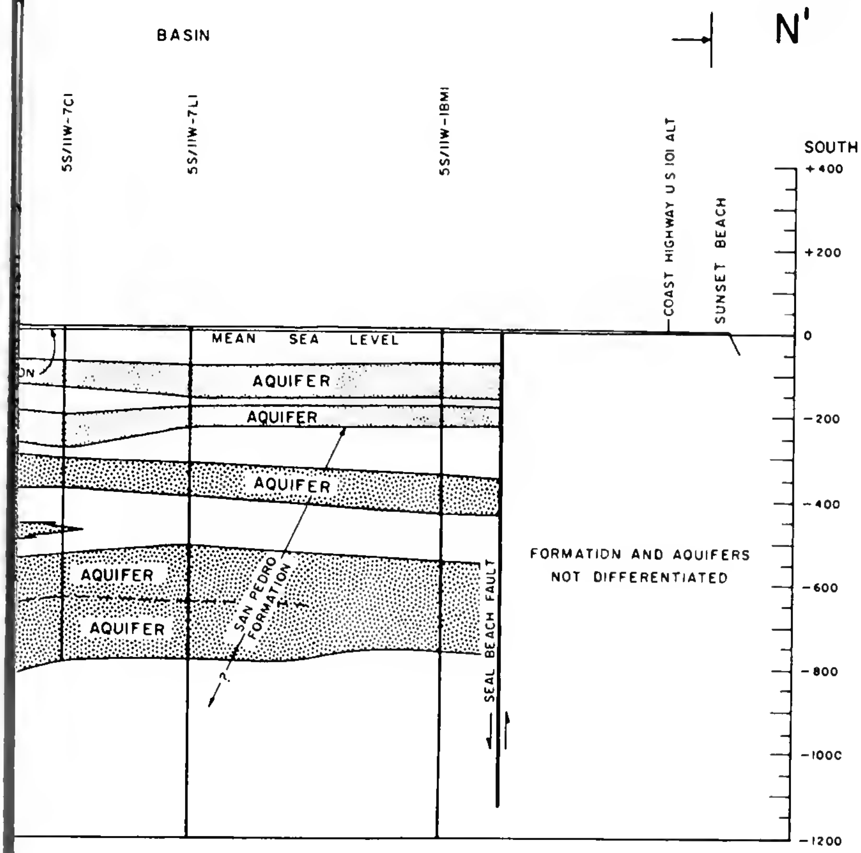
GROUND WATER GEOLOGY OF THE COASTAL PLAIN OF LOS ANGELES COUNTY

IDEALIZED GEOLOGIC SECTIONS M-M'-M'' AND N-N'

HORIZONTAL SCALE OF FEET

2000 0 2000 4000 6000

1961



LEGEND

AQUICLUDES AND DEEPER UNDIFFERENTIATED FORMATIONS

AQUIFERS IN RECENT ALLUVIUM (INCLUDES THE GASPUR AND BALLONA AQUIFERS)

AQUIFERS IN LAKEWOOD FORMATION (INCLUDES THE ARTESIA, EXPOSITION, GAGE, AND GARDENA AQUIFERS)

AQUIFERS IN SAN PEDRO FORMATION (INCLUDES THE HOLLYDALE, JEFFERSON, LYNWOOD, SILVERADO, AND SUNNYSIDE AQUIFERS)

WATER WELLS

OIL WELLS

FAULTS

* BOUNDARY BETWEEN FOREBAY AND PRESSURE AREA AS SHOWN ON PLATE 2 OF THIS REPORT

NOTE: LOCATIONS OF GEOLOGIC SECTIONS ARE SHOWN ON PLATE 3A AND 3B

STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN CALIFORNIA DISTRICT

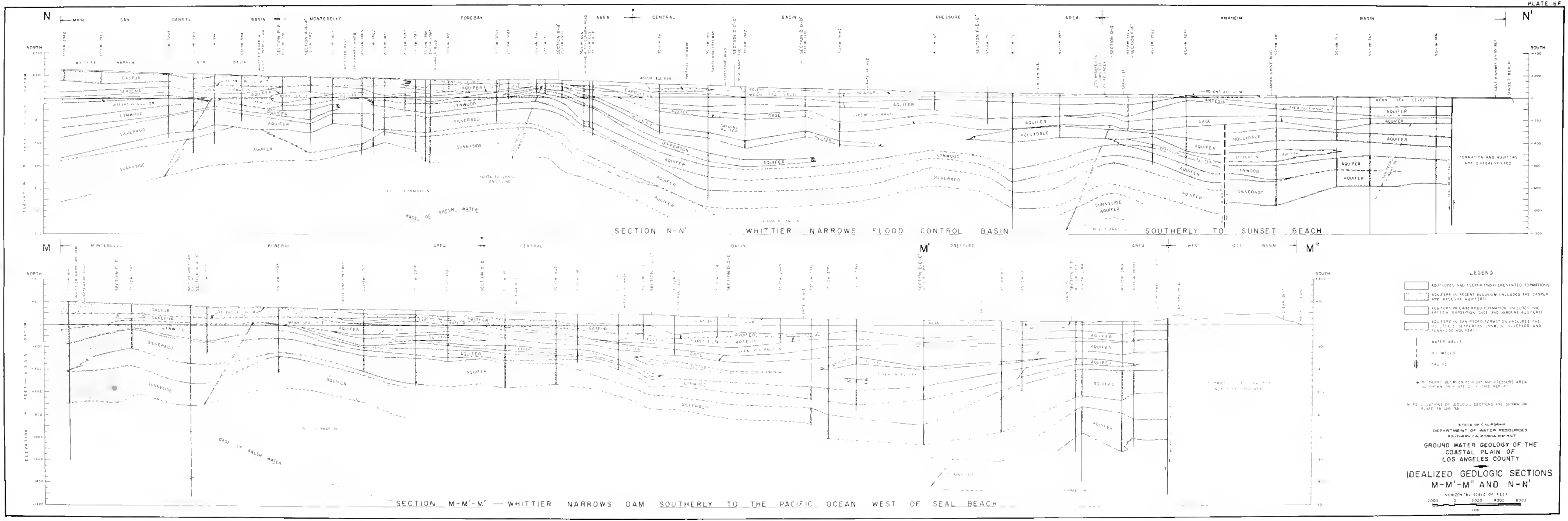
GROUND WATER GEOLOGY OF THE COASTAL PLAIN OF LOS ANGELES COUNTY

IDEALIZED GEOLOGIC SECTIONS M-M'-M" AND N-N'

HORIZONTAL SCALE OF FEET

2000 0 2000 4000 6000

1961



LEGEND

WATER WELLS

OIL WELLS

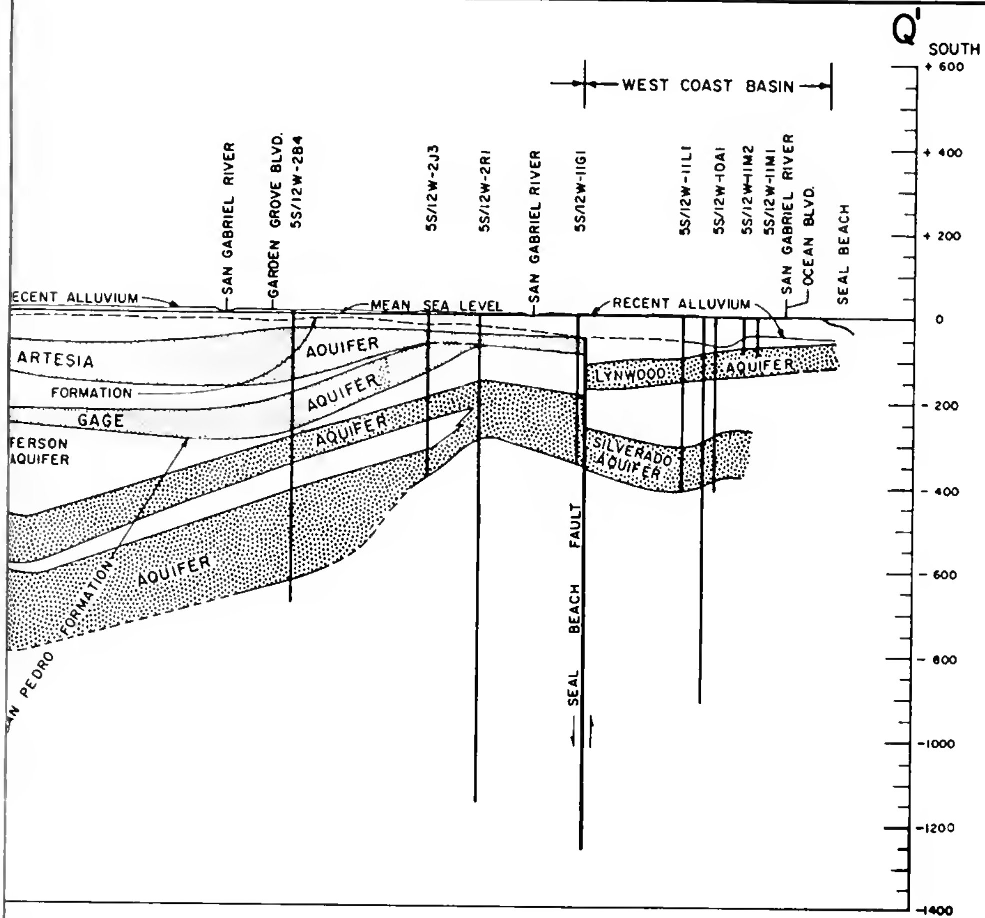
FAULTS

STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN CALIFORNIA DISTRICT

GROUND WATER GEOLOGY OF THE COASTAL PLAIN OF LOS ANGELES COUNTY

IDEALIZED GEOLOGIC SECTIONS M-M'-M'' AND N-N'

HORIZONTAL SCALE OF FEET
2000 0 2000 4000 6000



LEGEND

AQUICLUDES AND DEEPER UNDIFFERENTIATED FORMATIONS

AQUIFERS IN RECENT ALLUVIUM (INCLUDES THE GASPUR AND BALLONA AQUIFERS)

AQUIFERS IN LAKEWOOD FORMATION (INCLUDES THE ARTESIA, EXPOSITION, GAGE, AND GARDENA AQUIFERS)

AQUIFERS IN SAN PEDRO FORMATION (INCLUDES THE HOLLYDALE, JEFFERSON, LYNWOOD, SILVERADO, AND SUNNYSIDE AQUIFERS)

WATER WELLS

OIL WELLS

FAULTS

NOTE: LOCATIONS OF GEOLOGIC SECTIONS ARE SHOWN ON PLATE 3A AND 3B

STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN CALIFORNIA DISTRICT

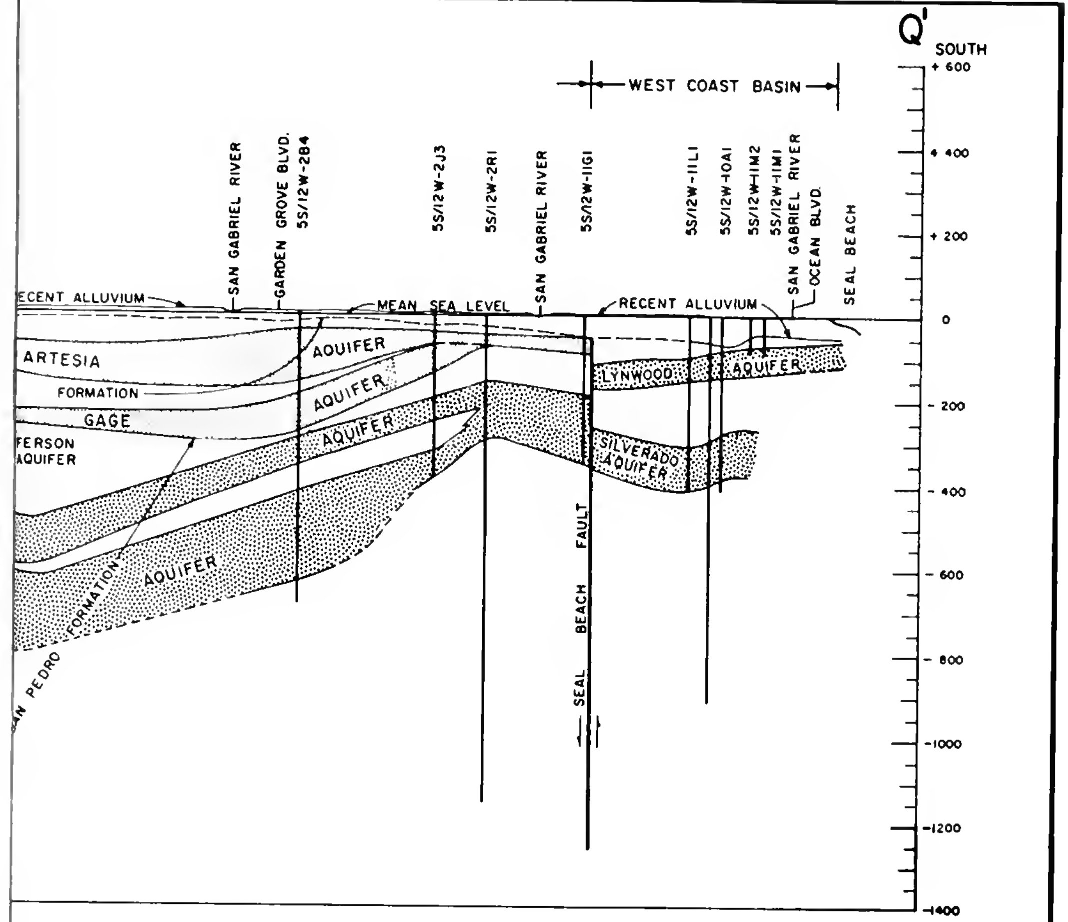
GROUND WATER GEOLOGY OF THE COASTAL PLAIN OF LOS ANGELES COUNTY

IDEALIZED GEOLOGIC SECTIONS H-H', P-P', AND Q-Q'

HORIZONTAL SCALE OF FEET

2000 0 2000 4000 6000

1961



LEGEND

AQUICLUDES AND DEEPER UNDIFFERENTIATED FORMATIONS

AQUIFERS IN RECENT ALLUVIUM (INCLUDES THE GASPUR AND BALLONA AQUIFERS)

AQUIFERS IN LAKEWOOD FORMATION (INCLUDES THE ARTESIA, EXPOSITION, GAGE, AND GARDENA AQUIFERS)

AQUIFERS IN SAN PEDRO FORMATION (INCLUDES THE HOLLYDALE, JEFFERSON, LYNWOOD, SILVERADO, AND SUNNYSIDE AQUIFERS)

WATER WELLS

OIL WELLS

FAULTS

NOTE. LOCATIONS OF GEOLOGIC SECTIONS ARE SHOWN ON PLATE 3A AND 3B

STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN CALIFORNIA DISTRICT

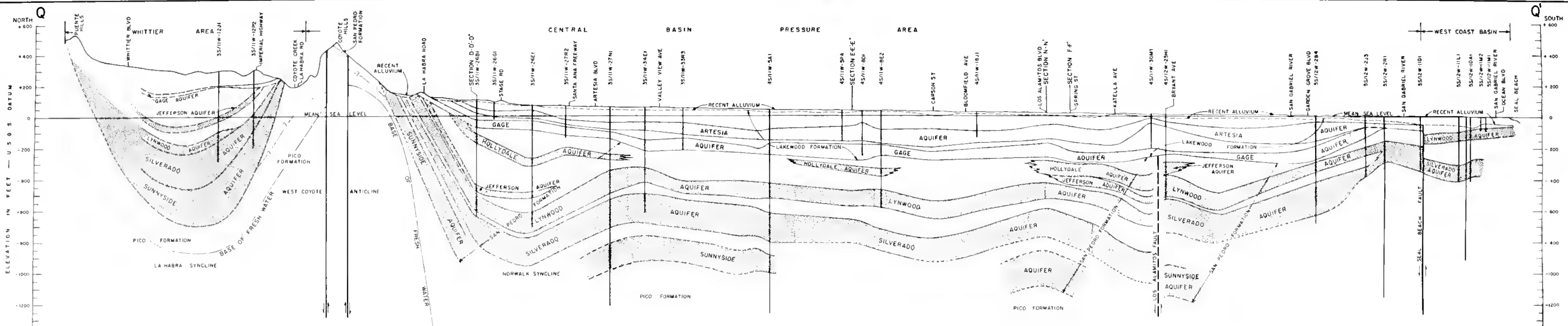
GROUND WATER GEOLOGY OF THE COASTAL PLAIN OF LOS ANGELES COUNTY

IDEALIZED GEOLOGIC SECTIONS H-H', P-P', AND Q-Q'

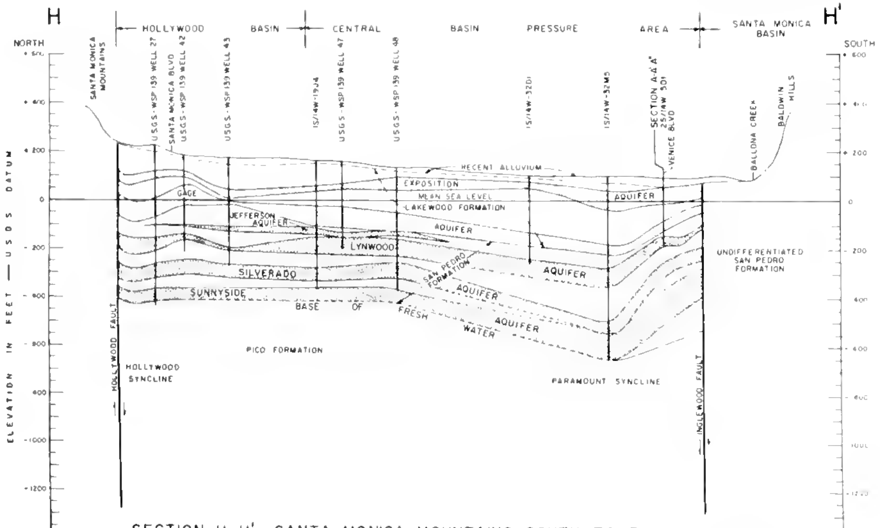
HORIZONTAL SCALE OF FEET

2000 0 2000 4000 6000

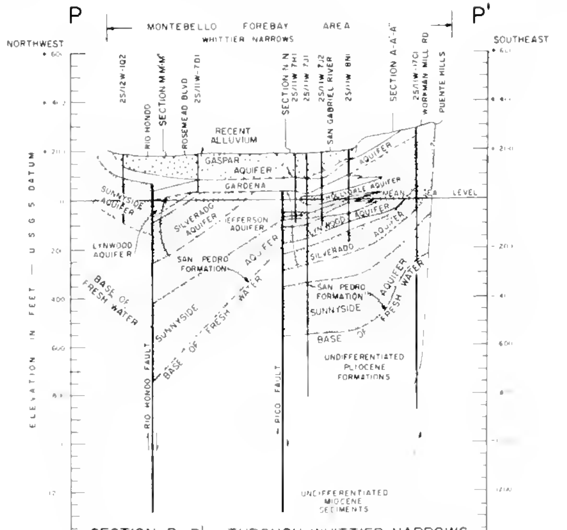
1961



SECTION Q-Q' — ALONG ORANGE COUNTY LINE FROM PUENTE HILLS TO SEAL BEACH



SECTION H-H' — SANTA MONICA MOUNTAINS SOUTH TO BALDWIN HILLS



SECTION P-P' — THROUGH WHITTIER NARROWS

LEGEND

- AQUICLUDES AND DEEPER UNDIFFERENTIATED FORMATIONS
- AQUIFERS IN RECENT ALLUVIUM (INCLUDES THE GASPUR AND BALLONA AQUIFERS)
- AQUIFERS IN LAKEWOOD FORMATION (INCLUDES THE ARTESIA, EXPOSITION, GAGE AND GARDENA AQUIFERS)
- AQUIFERS IN SAN PEDRO FORMATION (INCLUDES THE HOLLYDALE, JEFFERSON, LYNWOOD, SILVERADO, AND SUNNYSIDE AQUIFERS)
- WATER WELLS
- OIL WELLS
- FAULTS

NOTE: LOCATIONS OF GEOLOGIC SECTIONS ARE SHOWN ON PLATE 3A AND 3B

STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN CALIFORNIA DISTRICT

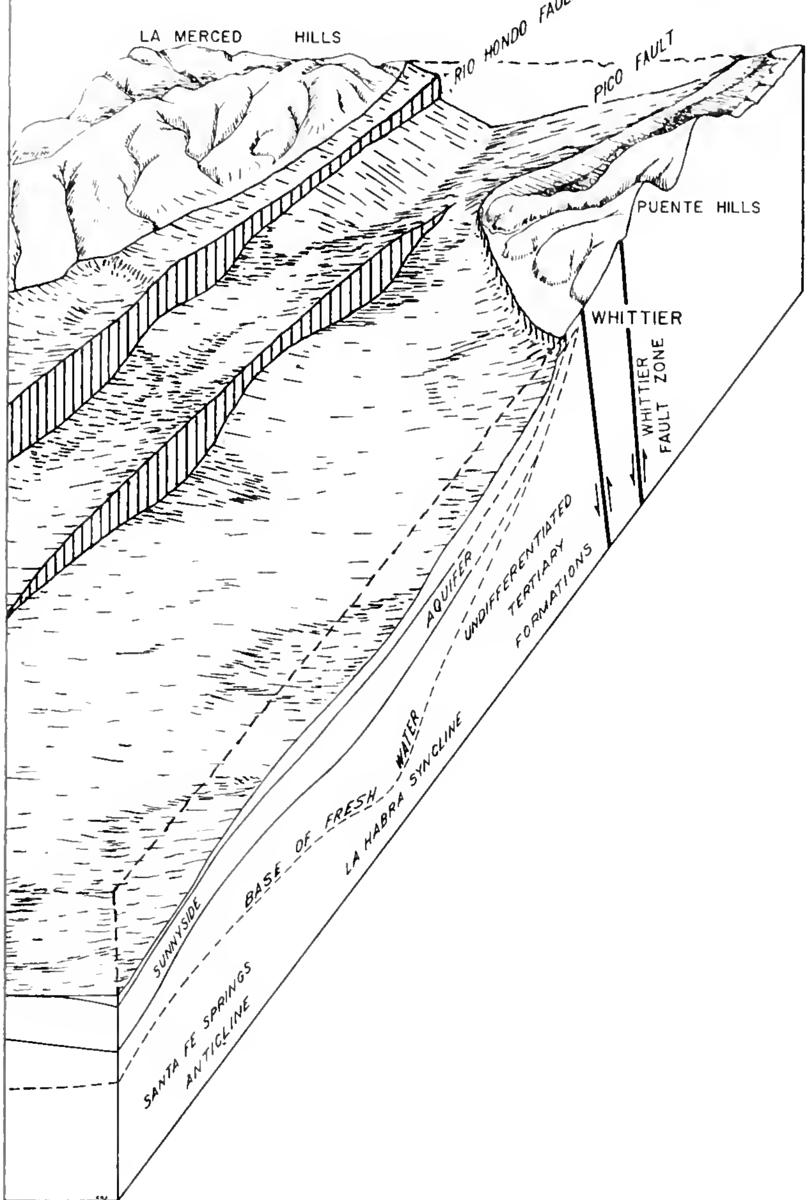
GROUND WATER GEOLOGY OF THE COASTAL PLAIN OF LOS ANGELES COUNTY

IDEALIZED GEOLOGIC SECTIONS H-H', P-P', AND Q-Q'

HORIZONTAL SCALE OF FEET

2000 0 2000 4000 6000

1961



R

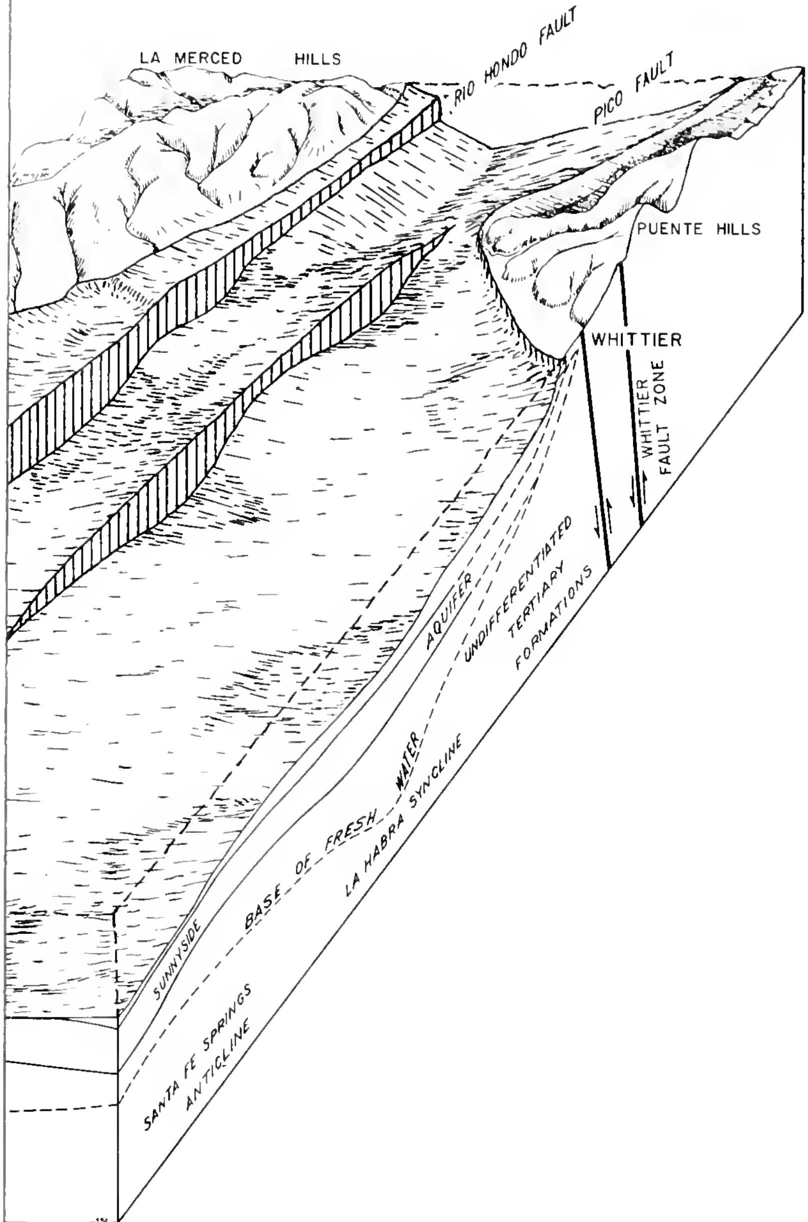
STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN CALIFORNIA DISTRICT

GROUND WATER GEOLOGY OF THE COASTAL PLAIN OF LOS ANGELES COUNTY

CUT-AWAY DIAGRAMS OF AQUIFERS IN VICINITY OF WHITTIER NARROWS

HORIZONTAL SCALE OF FEET
1000 0 1000 2000

1961



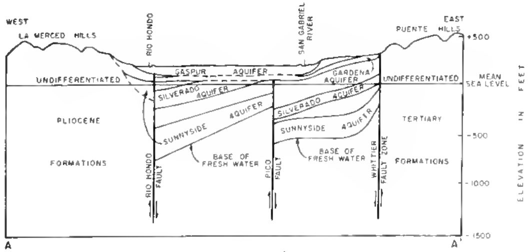
STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN CALIFORNIA DISTRICT

GROUND WATER GEOLOGY OF THE COASTAL PLAIN OF LOS ANGELES COUNTY

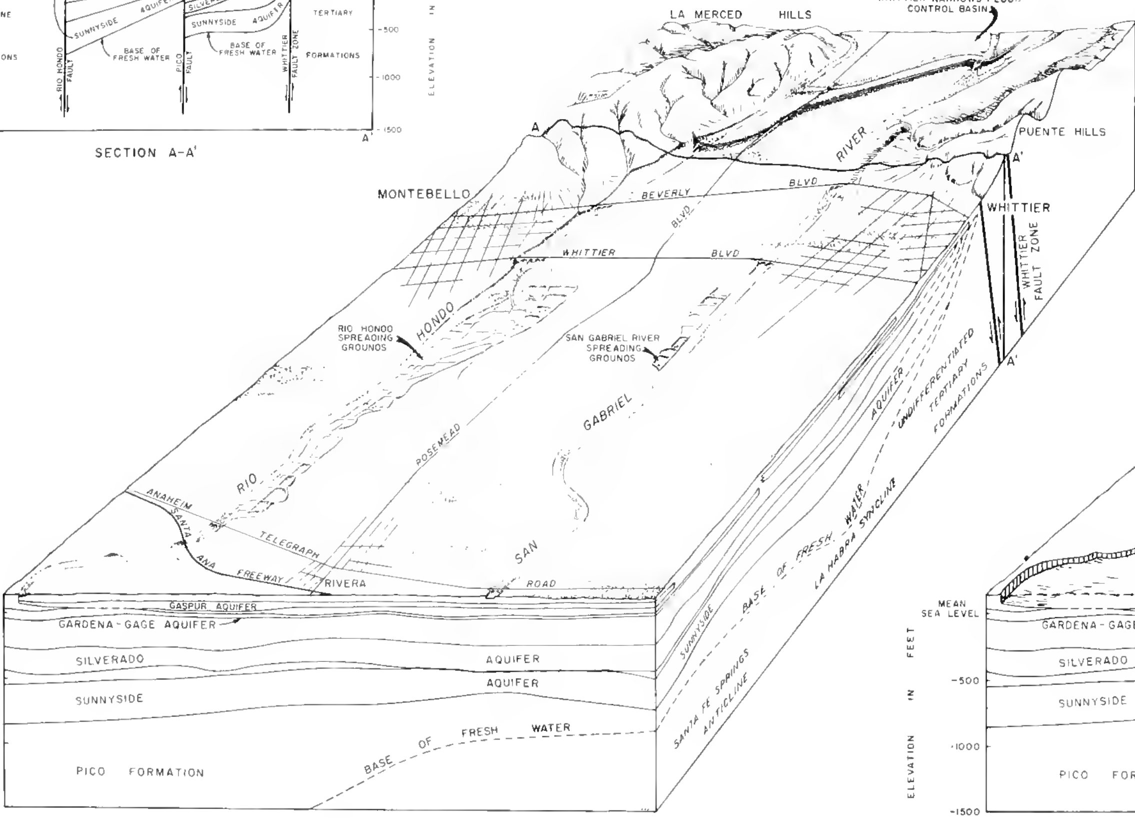
CUT-AWAY DIAGRAMS OF AQUIFERS IN VICINITY OF WHITTIER NARROWS

HORIZONTAL SCALE OF FEET
1000 0 1000 2000

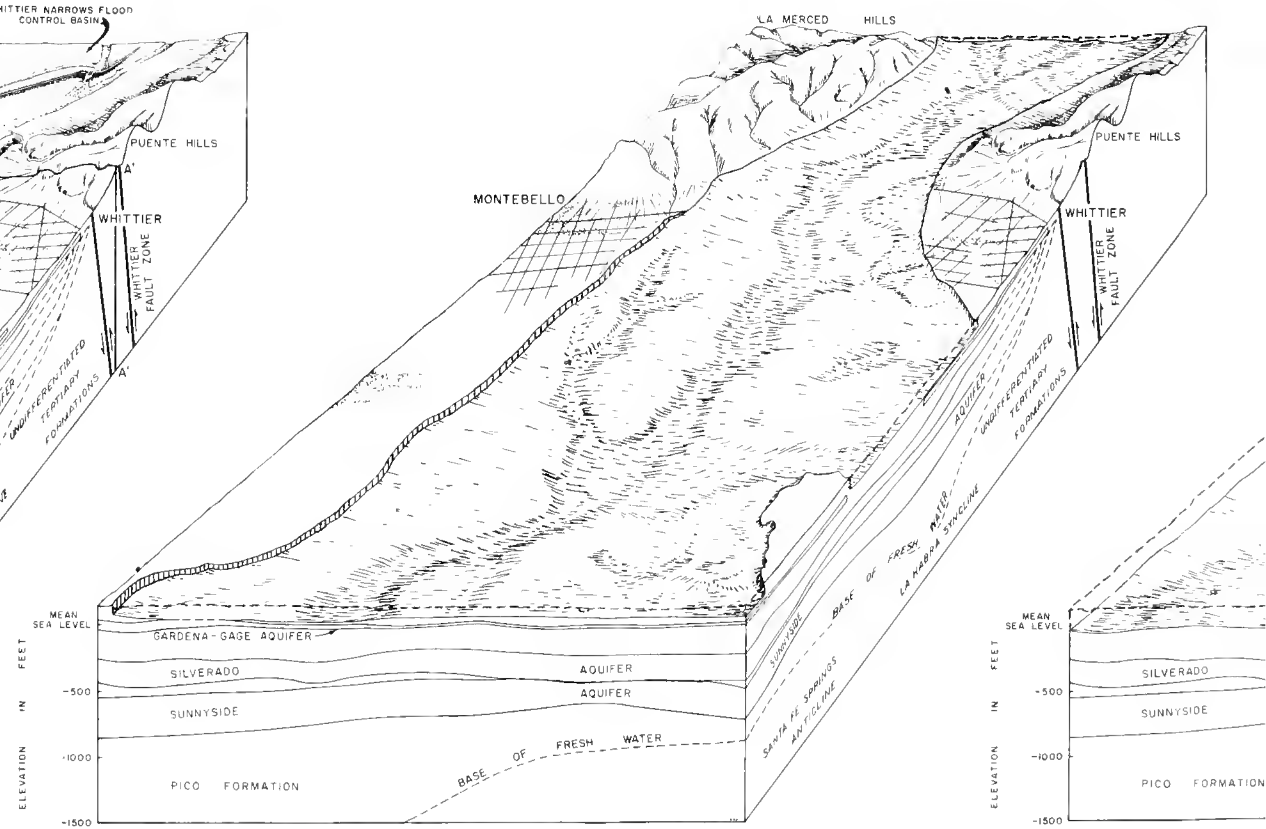
1961



SECTION A-A'



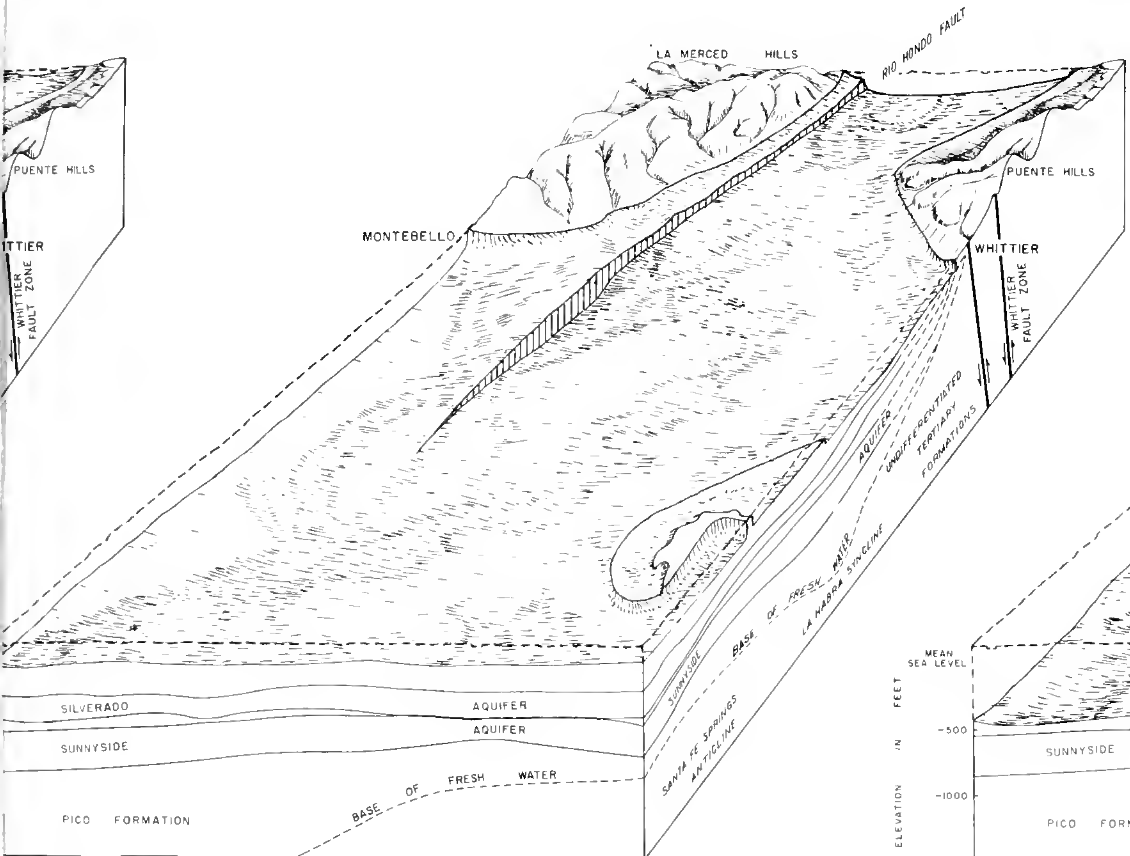
VIEW I PRESENT LAND SURFACE



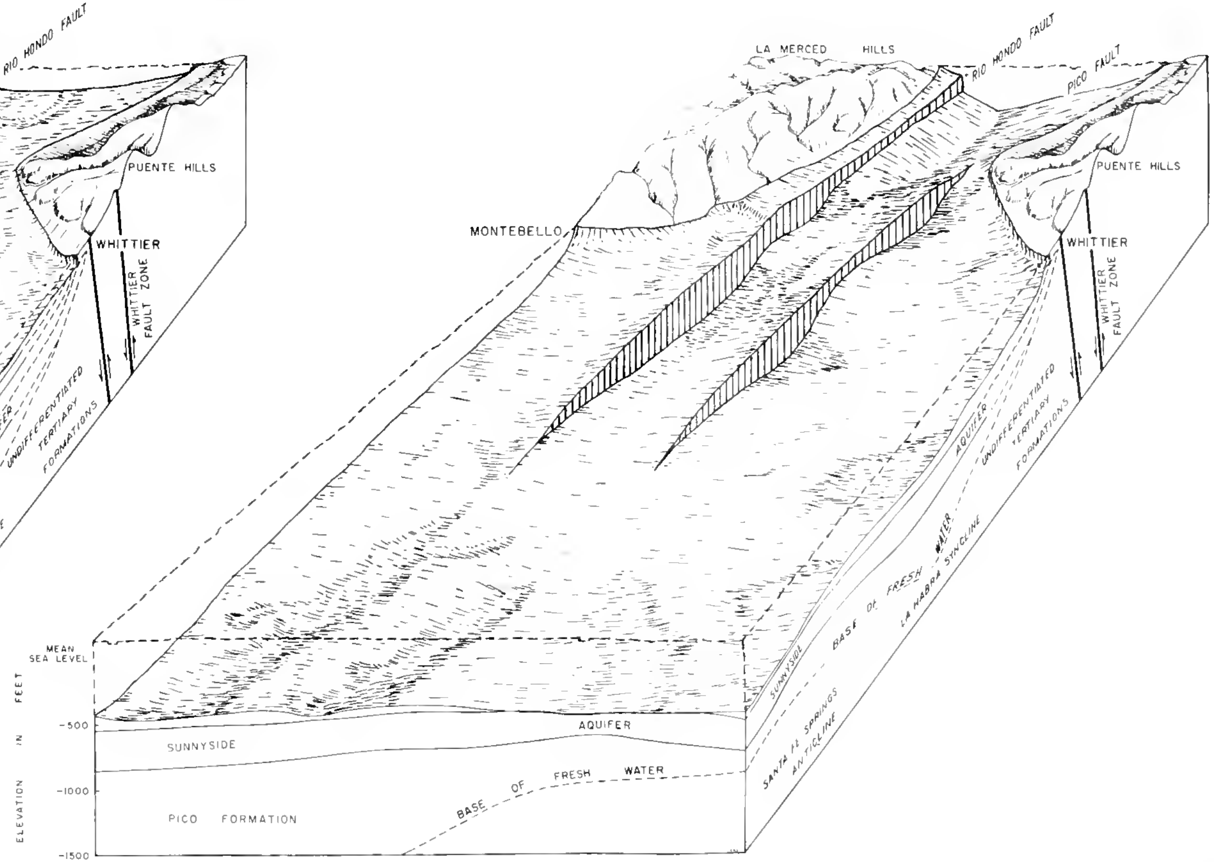
VIEW II BASE OF THE GASPUR AQUIFER
(OVERLYING SEDIMENTS REMOVED)

VIEW III BA
(OV

NOTE: VERTICAL SCALE IS TWICE THE HORIZONTAL SCALE



VIEW III BASE OF THE GARDENA-GAGE AQUIFER
(OVERLYING SEDIMENTS REMOVED)



VIEW IV BASE OF THE SILVERADO AQUIFER
(OVERLYING SEDIMENTS REMOVED)

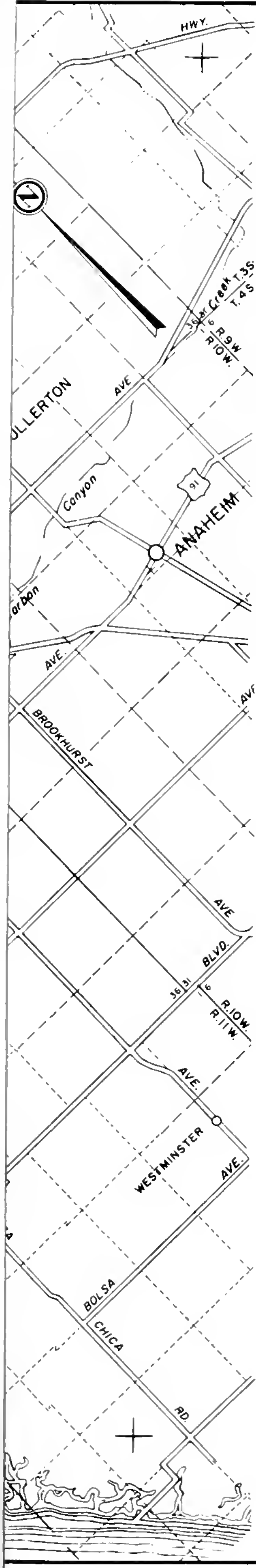
STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN CALIFORNIA DISTRICT

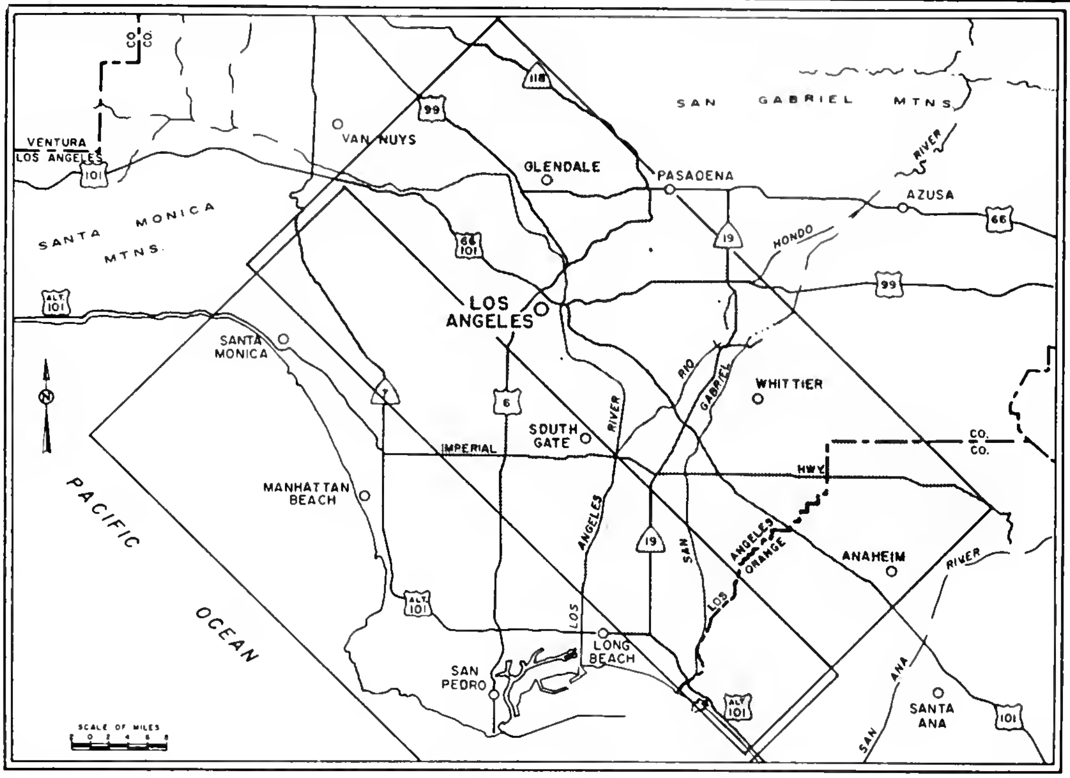
GROUND WATER GEOLOGY OF THE COASTAL PLAIN OF LOS ANGELES COUNTY

CUT-AWAY DIAGRAMS OF AQUIFERS IN VICINITY OF WHITTIER NARROWS

HORIZONTAL SCALE OF FEET
1000 0 1000 2000

1961





LOCATION MAP

LEGEND

SURFACE FEATURES

Qal	RECENT ALLUVIUM
Qpu	UPPER PLEISTOCENE DEPOSITS
	LOWER PLEISTOCENE DEPOSITS
	NONWATER-BEARING ROCKS

SUBSURFACE FEATURES

BOUNDARY OF BELLFLOWER AQUICLUDE (DASHED WHERE LOCATION IS APPROXIMATE)

-60- LINES OF EQUAL ELEVATION ON THE BASE OF THE BELLFLOWER AQUICLUDE (DASHED WHERE CONTROL IS POOR)

FAULT (DASHED WHERE APPROXIMATELY LOCATED)

KNOWN AREAS WHERE THE BELLFLOWER AQUICLUDE IS ABSENT AND THE AQUIFERS PRESENT ARE IN HYDRAULIC CONTINUITY WITH THE SURFACE

BOUNDARY OF THE GASPUR AQUIFER

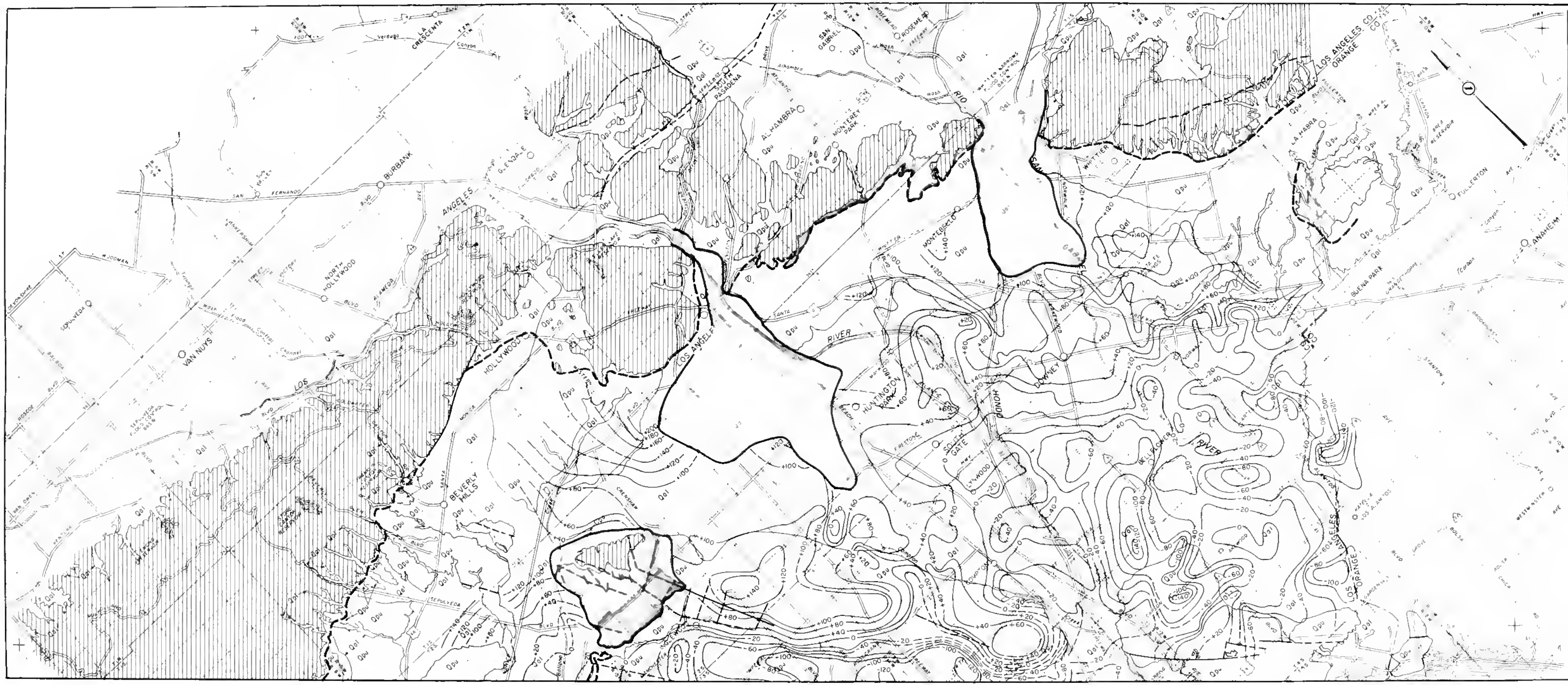
STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN CALIFORNIA DISTRICT

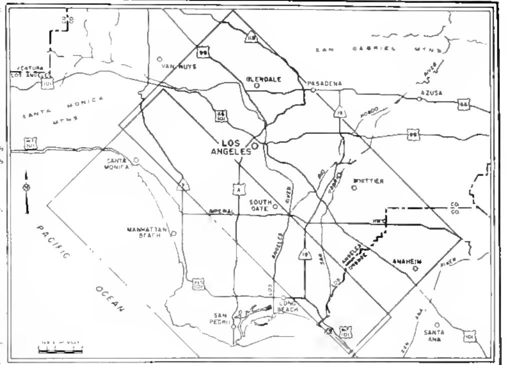
GROUND WATER GEOLOGY OF THE
COASTAL PLAIN OF
LOS ANGELES COUNTY

LINES OF EQUAL ELEVATION ON THE BASE OF THE BELLFLOWER AQUICLUDE

SCALE OF MILES
1 0 1 2 3

1961





LOCATION MAP

LEGEND

SURFACE FEATURES

Qal
Qpu

SUBSURFACE FEATURES

-60-

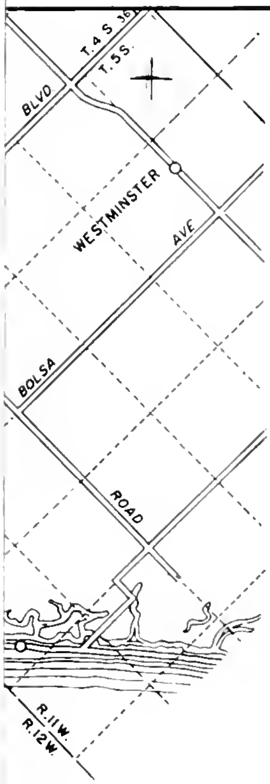
STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN CALIFORNIA DISTRICT

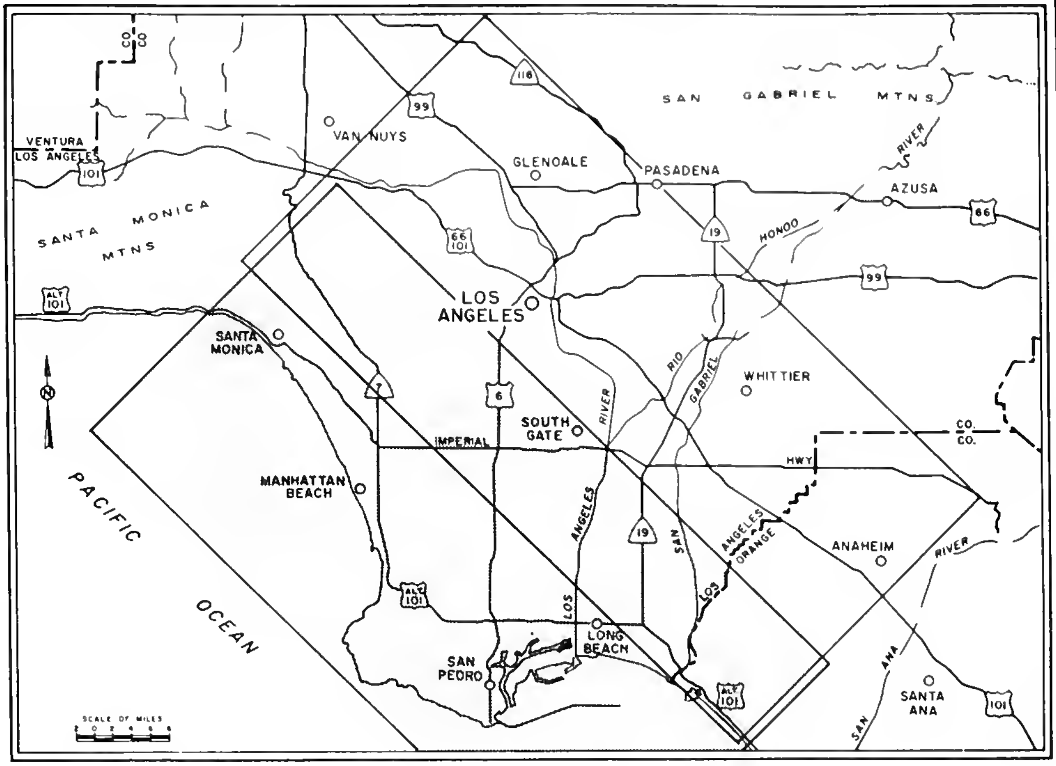
GROUND WATER GEOLOGY OF THE
COASTAL PLAIN OF
LOS ANGELES COUNTY

LINES OF EQUAL ELEVATION ON THE BASE
OF THE BELLFLOWER AQUICLUDE

SCALE OF MILES

1961





LOCATION MAP

LEGEND

SURFACE FEATURES

Qal	RECENT ALLUVIUM
Qpu	UPPER PLEISTOCENE DEPOSITS
	LOWER PLEISTOCENE DEPOSITS
	NONWATER-BEARING ROCKS

SUBSURFACE FEATURES

	BOUNDARY OF BELLFLOWER AQUICLUDE (DASHED WHERE LOCATION IS APPROXIMATE)
60	LINES OF EQUAL ELEVATION ON THE BASE OF THE BELLFLOWER AQUICLUDE (DASHED WHERE CONTROL IS POOR)
	FAULT (DASHED WHERE APPROXIMATELY LOCATED)
	KNOWN AREAS WHERE THE BELLFLOWER AQUICLUDE IS ABSENT AND THE AQUIFERS PRESENT ARE IN HYDRAULIC CONTINUITY WITH THE SURFACE
	BOUNDARY OF THE GASPUR AQUIFER

STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN CALIFORNIA DISTRICT

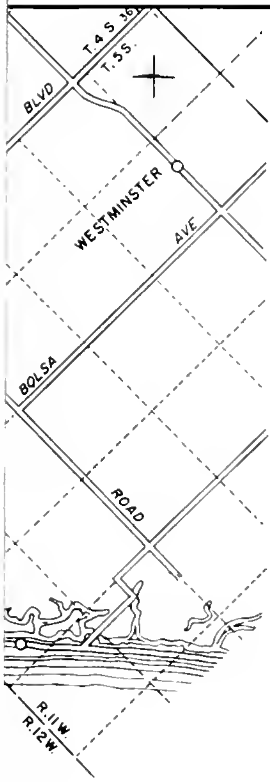
GROUND WATER GEOLOGY OF THE COASTAL PLAIN OF LOS ANGELES COUNTY

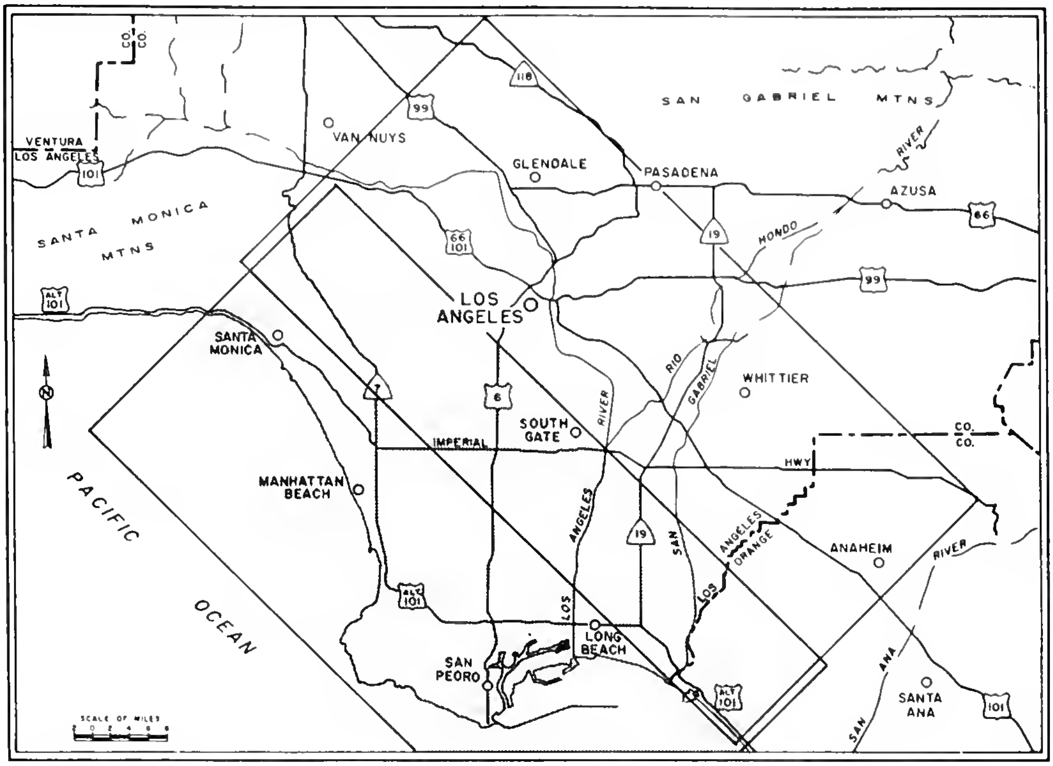
LINES OF EQUAL ELEVATION ON THE BASE OF THE BELLFLOWER AQUICLUDE

SCALE OF MILES

1 0 1 2 3

1961





LOCATION MAP

LEGEND

SURFACE FEATURES

Qal	RECENT ALLUVIUM
Qpu	UPPER PLEISTOCENE DEPOSITS
	LOWER PLEISTOCENE DEPOSITS
	NONWATER-BEARING ROCKS

SUBSURFACE FEATURES

BOUNDARY OF BELLFLOWER AQUICLUDE (DASHED WHERE LOCATION IS APPROXIMATE)

-60- LINES OF EQUAL ELEVATION ON THE BASE OF THE BELLFLOWER AQUICLUDE (DASHED WHERE CONTROL IS POOR)

FAULT (DASHED WHERE APPROXIMATELY LOCATED)

KNOWN AREAS WHERE THE BELLFLOWER AQUICLUDE IS ABSENT AND THE AQUIFERS PRESENT ARE IN HYDRAULIC CONTINUITY WITH THE SURFACE

BOUNDARY OF THE GASPUR AQUIFER

STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN CALIFORNIA DISTRICT

GROUND WATER GEOLOGY OF THE COASTAL PLAIN OF LOS ANGELES COUNTY

LINES OF EQUAL ELEVATION ON THE BASE OF THE BELLFLOWER AQUICLUDE

SCALE OF MILES
1 0 1 2 3

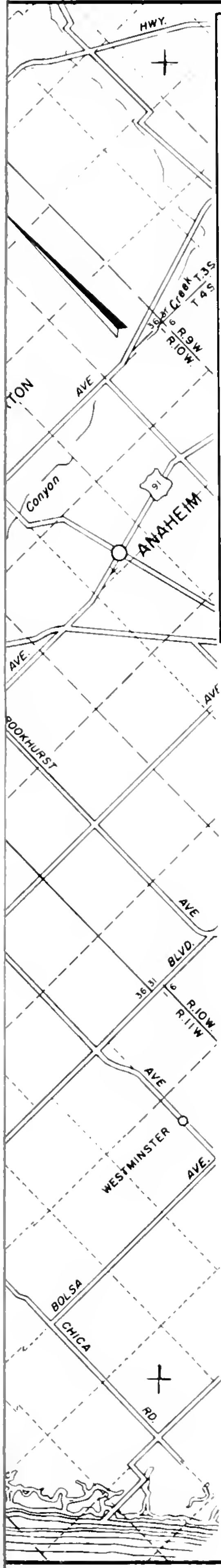
1961

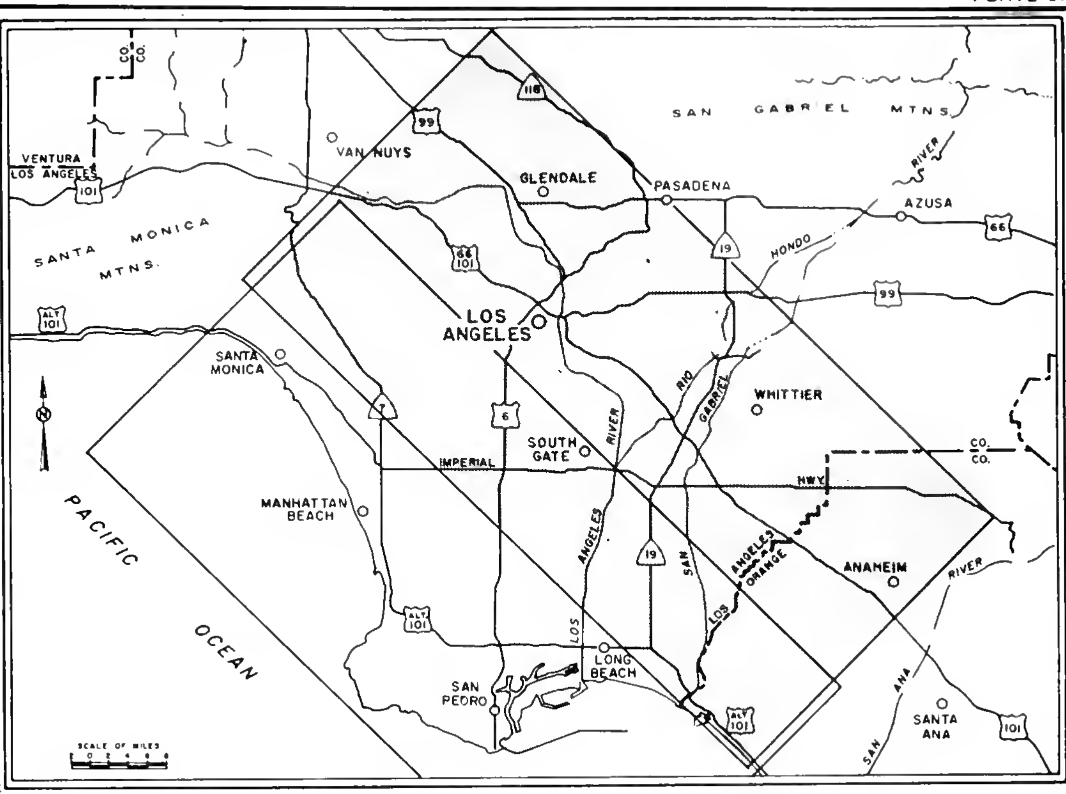
STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN CALIFORNIA DISTRICT
GROUND WATER GEOLOGY OF THE
COASTAL PLAIN OF
LOS ANGELES COUNTY

LINES OF EQUAL ELEVATION ON THE BASE
OF THE BELLFLOWER AQUICLUDE

SCALE OF MILES

1961





LOCATION MAP

LEGEND

FEATURES

Qal	RECENT ALLUVIUM
Qpu	UPPER PLEISTOCENE DEPOSITS
	LOWER PLEISTOCENE DEPOSITS
	NONWATER-BEARING ROCKS

SUBSURFACE FEATURES

	BOUNDARY OF BELLFLOWER AQUICLUDE (DASHED WHERE LOCATION IS APPROXIMATE)
60	LINES OF EQUAL THICKNESS OF THE BELLFLOWER AQUICLUDE (DASHED WHERE CONTROL IS POOR)
	FAULT (DASHED WHERE APPROXIMATELY LOCATED)
	KNOWN AREAS WHERE THE BELLFLOWER AQUICLUDE IS ABSENT AND THE AQUIFERS PRESENT ARE IN HYDRAULIC CONTINUITY WITH THE SURFACE
	KNOWN AREAS WHERE THE BELLFLOWER AQUICLUDE IS COMPOSED LARGELY OF SANDY AND GRAVELLY CLAY
	BOUNDARY OF THE GASPUR AQUIFER

STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN CALIFORNIA DISTRICT

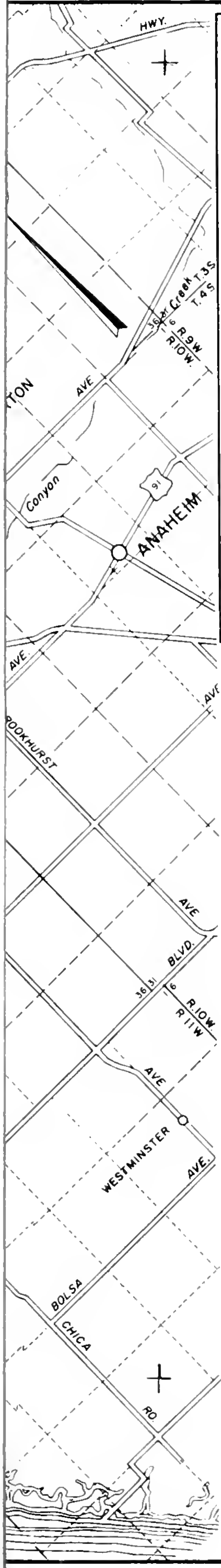
GROUND WATER GEOLOGY OF THE COASTAL PLAIN OF LOS ANGELES COUNTY

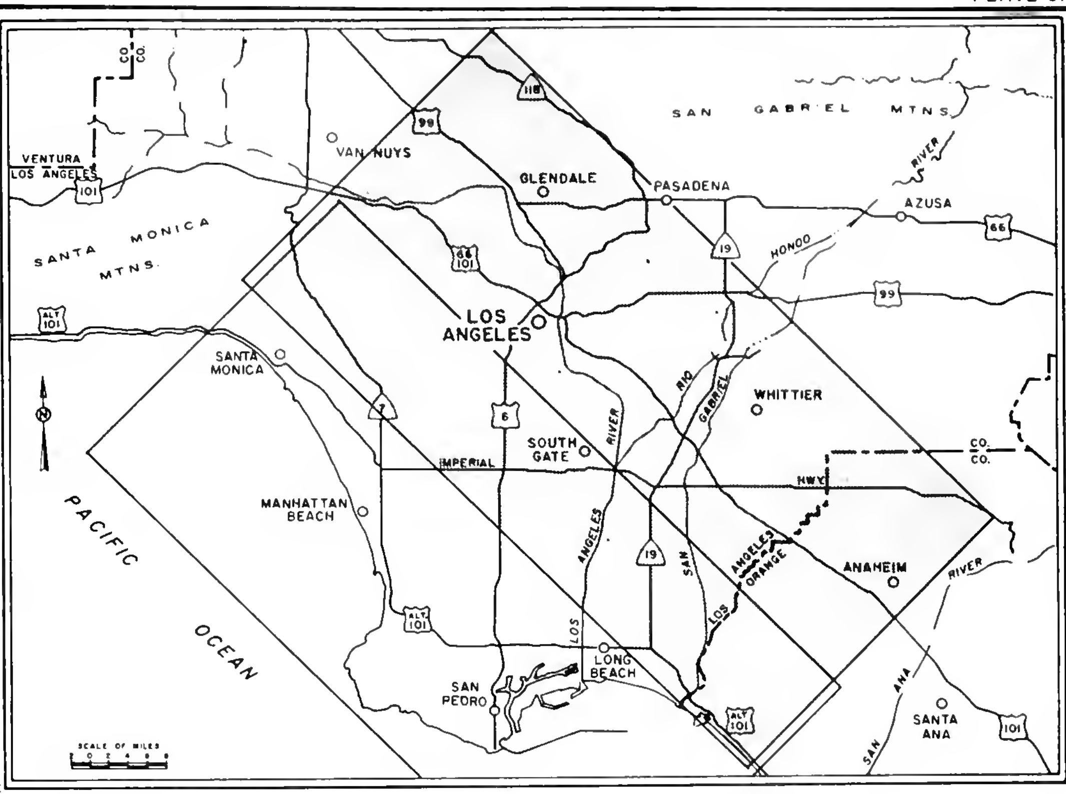
LINES OF EQUAL THICKNESS OF THE BELLFLOWER AQUICLUDE

SCALE OF MILES

1 0 1 2 3

1961





LOCATION MAP

LEGEND

SURFACE FEATURES

Qal	RECENT ALLUVIUM
Qpu	UPPER PLEISTOCENE DEPOSITS
	LOWER PLEISTOCENE DEPOSITS
	NONWATER-BEARING ROCKS

SUBSURFACE FEATURES

BOUNDARY OF BELLFLOWER AQUICLUDE (DASHED WHERE LOCATION IS APPROXIMATE)

60 — LINES OF EQUAL THICKNESS OF THE BELLFLOWER AQUICLUDE (DASHED WHERE CONTROL IS POOR)

FAULT (DASHED WHERE APPROXIMATELY LOCATED)

KNOWN AREAS WHERE THE BELLFLOWER AQUICLUDE IS ABSENT AND THE AQUIFERS PRESENT ARE IN HYDRAULIC CONTINUITY WITH THE SURFACE

KNOWN AREAS WHERE THE BELLFLOWER AQUICLUDE IS COMPOSED LARGELY OF SANDY AND GRAVELLY CLAY

BOUNDARY OF THE GASPUR AQUIFER

STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN CALIFORNIA DISTRICT

GROUND WATER GEOLOGY OF THE COASTAL PLAIN OF LOS ANGELES COUNTY

LINES OF EQUAL THICKNESS OF THE BELLFLOWER AQUICLUDE

SCALE OF MILES
1 0 1 2 3

1961

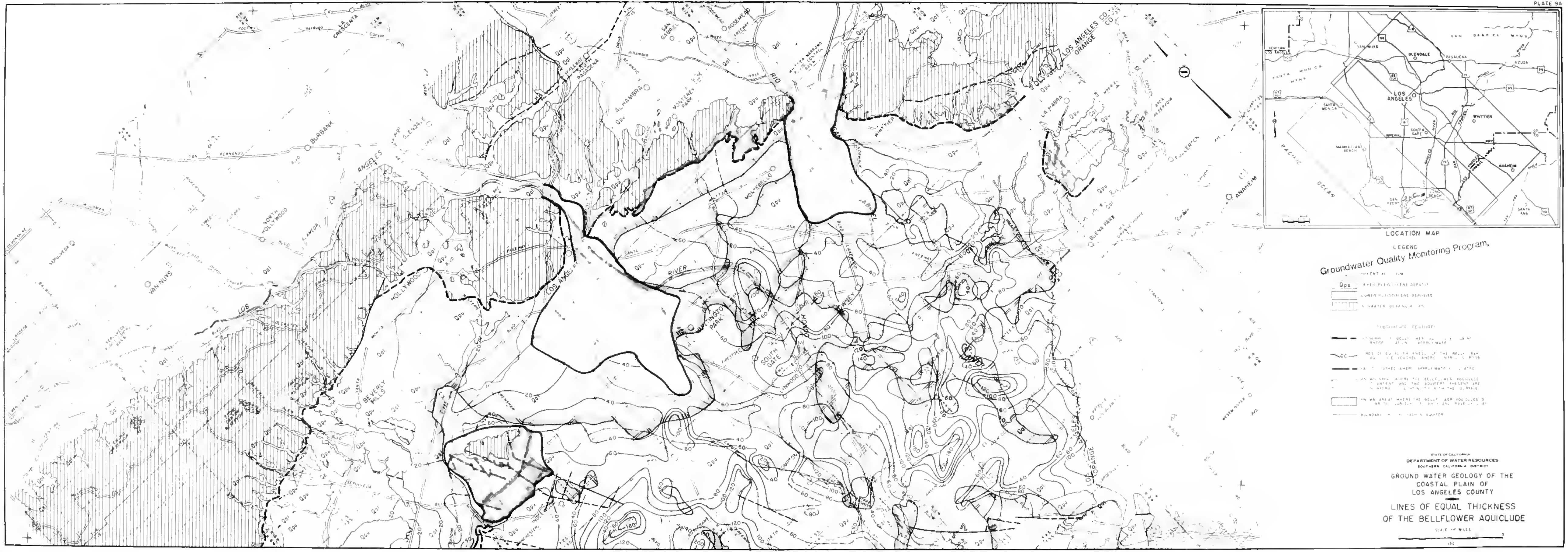
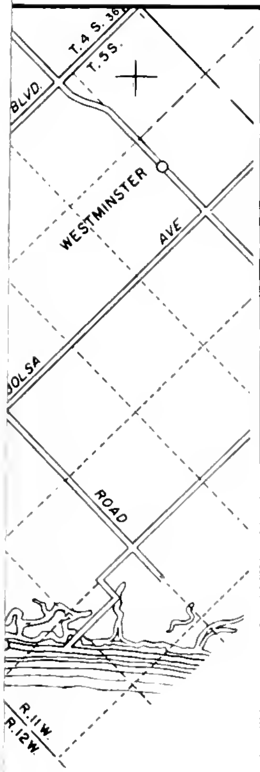
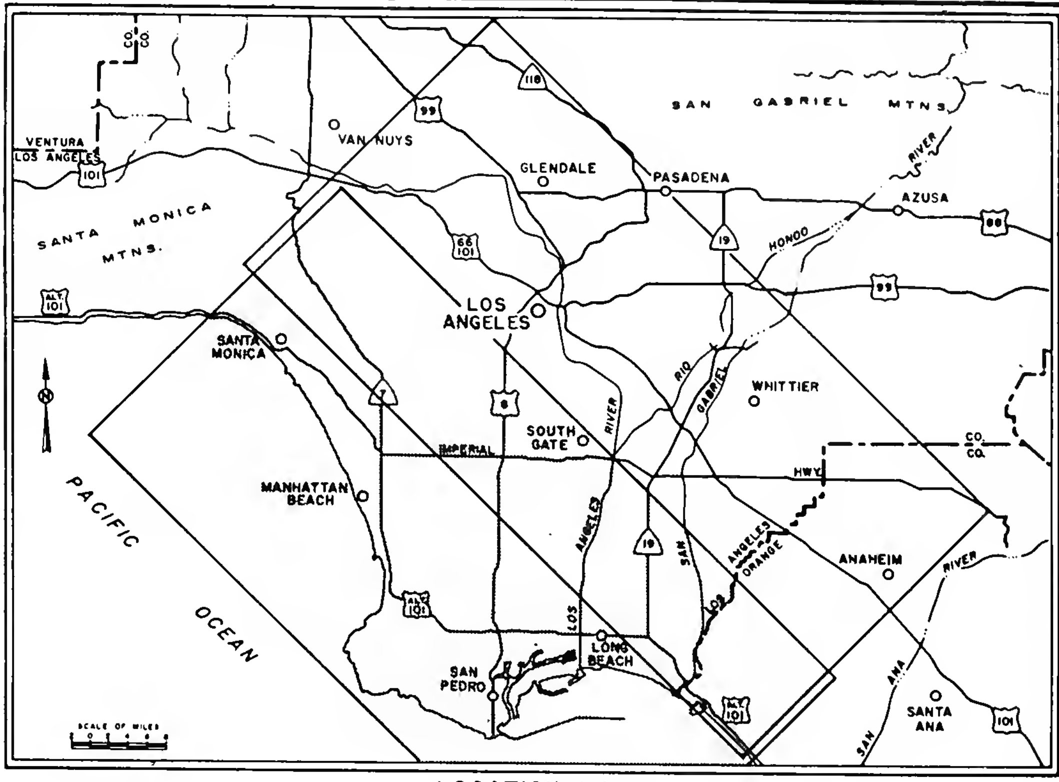


PLATE 9A
LOCATION MAP
LEGEND
Groundwater Quality Monitoring Program,
Qpu
SUBSURFACE FEATURES
STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN CALIFORNIA DISTRICT
GROUND WATER GEOLOGY OF THE
COASTAL PLAIN OF
LOS ANGELES COUNTY
LINES OF EQUAL THICKNESS
OF THE BELLFLOWER AQUICLUDE
SCALE OF MILES
LOS ANGELES CO.
ORANGE CO.
BURBANK
GLENDALE
NORTH HOLLYWOOD
VAN NUYS
HOLLYWOOD
BEVERLY HILLS
ALHAMBRA
MONTEREY PARK
MONTEBELLO
HUNTINGTON PARK
SOUTH GATE
LYNWOOD
ANAHEIM
LA HABRA
WHITTIER
LOS ANGELES
SANTA MONICA
PACIFIC
OCEAN
PASADENA
AZUSA
SAN PEDRO
LONG BEACH
SANTA ANA





LOCATION MAP

LEGEND

SURFACE FEATURES

Qal	RECENT ALLUVIUM
Qpu	UPPER PLEISTOCENE DEPOSITS
	LOWER PLEISTOCENE DEPOSITS
	NONWATER-BEARING ROCKS

SUBSURFACE FEATURES

BOUNDARY OF BELLFLOWER AQUICLUDE (DASHED WHERE LOCATION IS APPROXIMATE)

60 — LINES OF EQUAL THICKNESS OF THE BELLFLOWER AQUICLUDE (DASHED WHERE CONTROL IS POOR)

FAULT (DASHED WHERE APPROXIMATELY LOCATED)

KNOWN AREAS WHERE THE BELLFLOWER AQUICLUDE IS ABSENT AND THE AQUIFERS PRESENT ARE IN HYDRAULIC CONTINUITY WITH THE SURFACE

KNOWN AREAS WHERE THE BELLFLOWER AQUICLUDE IS COMPOSED LARGELY OF SANDY AND GRAVELLY CLAY

BOUNDARY OF THE GASPUR AQUIFER

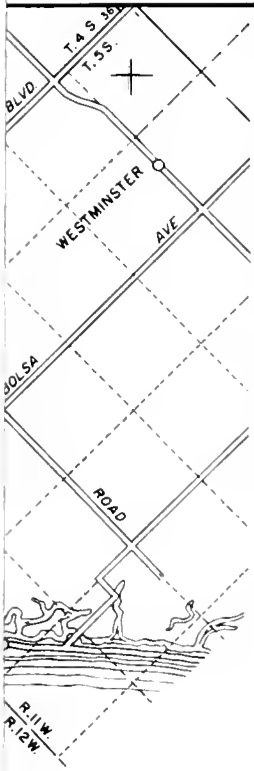
STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN CALIFORNIA DISTRICT

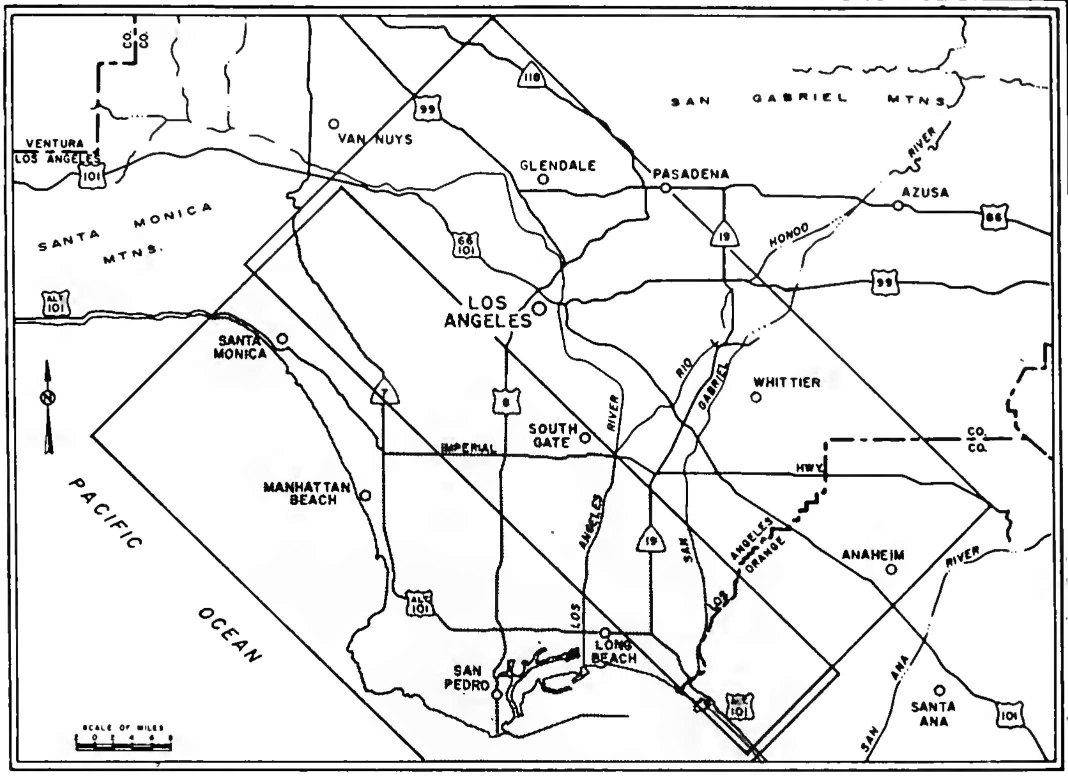
GROUND WATER GEOLOGY OF THE COASTAL PLAIN OF LOS ANGELES COUNTY

LINES OF EQUAL THICKNESS OF THE BELLFLOWER AQUICLUDE

SCALE OF MILES
1 0 1 2 3

1961





LOCATION MAP

LEGEND

SURFACE FEATURES

Qal	RECENT ALLUVIUM
Qpu	UPPER PLEISTOCENE DEPOSITS
	LOWER PLEISTOCENE DEPOSITS
	NONWATER-BEARING ROCKS

SUBSURFACE FEATURES

	BOUNDARY OF BELLFLOWER AQUICLUDE (DASHED WHERE LOCATION IS APPROXIMATE)
60	LINES OF EQUAL THICKNESS OF THE BELLFLOWER AQUICLUDE (DASHED WHERE CONTROL IS POOR)
	FAULT (DASHED WHERE APPROXIMATELY LOCATED)
	KNOWN AREAS WHERE THE BELLFLOWER AQUICLUDE IS ABSENT AND THE AQUIFERS PRESENT ARE IN HYDRAULIC CONTINUITY WITH THE SURFACE
	KNOWN AREAS WHERE THE BELLFLOWER AQUICLUDE IS COMPOSED LARGELY OF SANDY AND GRAVELLY CLAY
	BOUNDARY OF THE GASPUR AQUIFER

STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN CALIFORNIA DISTRICT

GROUND WATER GEOLOGY OF THE COASTAL PLAIN OF LOS ANGELES COUNTY

LINES OF EQUAL THICKNESS OF THE BELLFLOWER AQUICLUDE

SCALE OF MILES

1 0 1 2 3

1961

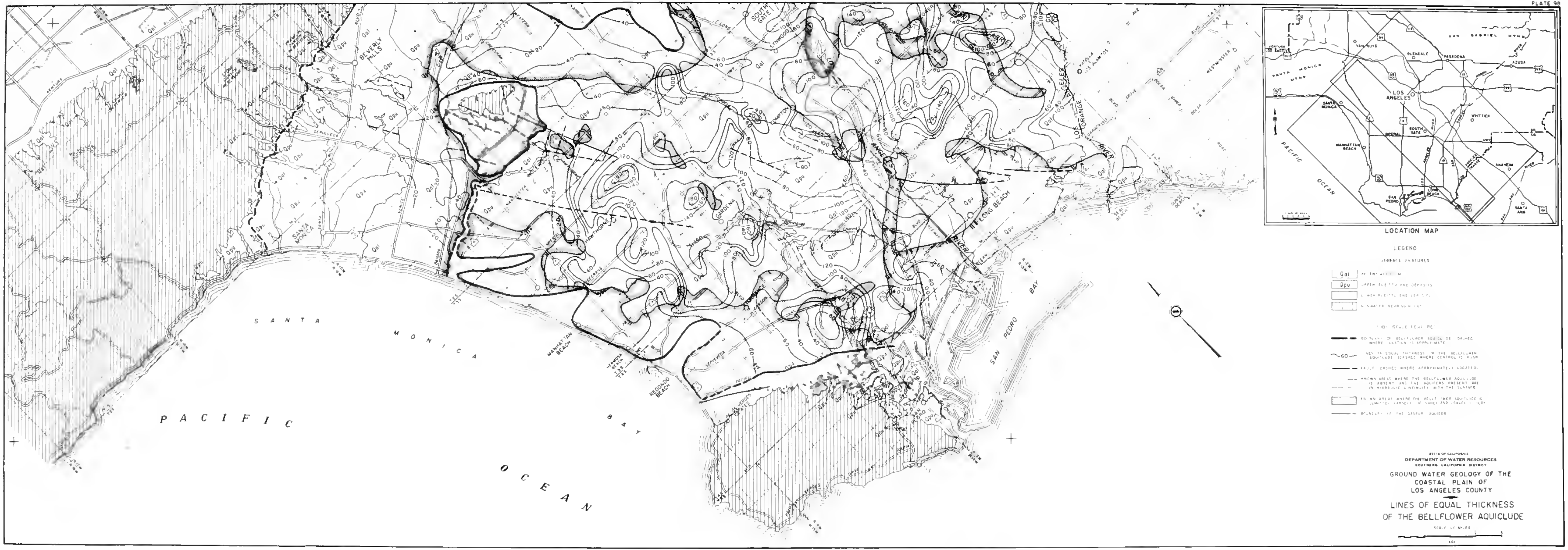
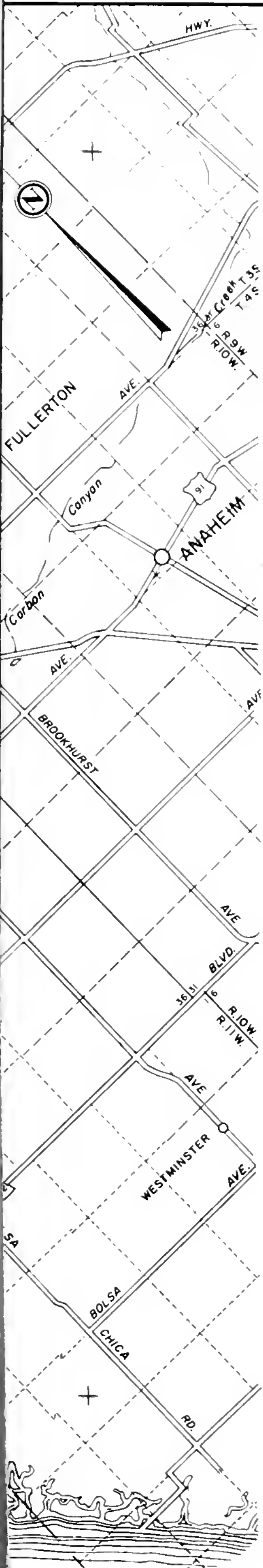
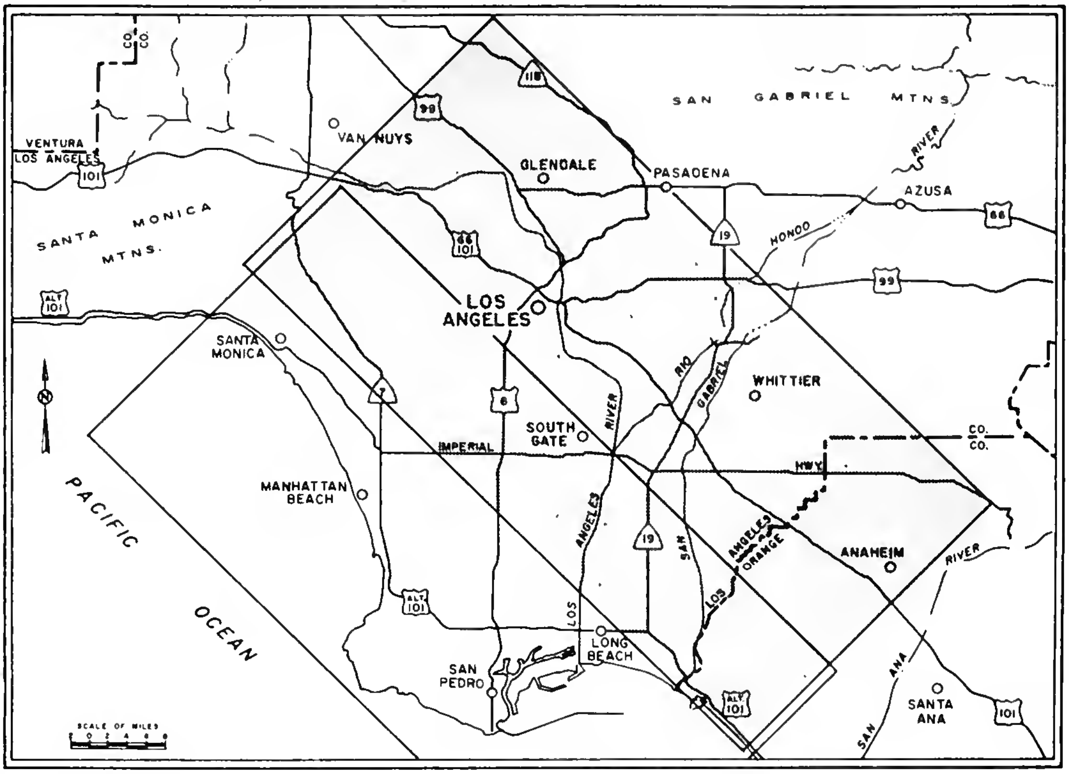


PLATE 9B
LOCATION MAP
LEGEND
Qal
Qpu
STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN CALIFORNIA DISTRICT
GROUND WATER GEOLOGY OF THE
COASTAL PLAIN OF
LOS ANGELES COUNTY
LINES OF EQUAL THICKNESS
OF THE BELLFLOWER AQUICLUDE
PACIFIC OCEAN
SANTA MONICA BAY
SAN PEDRO BAY
SANTA MONICA
BEVERLY HILLS
INGLEWOOD
HAWTHORNE
GARDENA
TORRANCE
MANHATTAN BEACH
HERMOSA BEACH
REDONDO BEACH
SOUTH GATE
LYNWOOD
COMPTON
LONG BEACH
SAN PEDRO
LOS ANGELES RIVER
SAN GABRIEL RIVER





LOCATION MAP

LEGEND

SURFACE FEATURES

Qal RECENT ALLUVIUM

Qpu UPPER PLEISTOCENE DEPOSITS

LOWER PLEISTOCENE DEPOSITS

NONWATER-BEARING ROCKS

SUBSURFACE FEATURES

BOUNDARY OF AQUIFERS (DASHED WHERE LOCATION IS APPROXIMATE)

-60- LINES OF EQUAL ELEVATION ON THE BASE OF THE GASPUR, BALLONA, ARTESIA, AND EXPOSITION AQUIFERS (DASHED WHERE CONTROL IS POOR)

FAULT (DASHED WHERE APPROXIMATELY LOCATED)

GASPUR AQUIFER

BALLONA AQUIFER

ARTESIA AQUIFER

EXPOSITION AQUIFER

KNOWN AREAS WHERE AQUIFERS ARE IN HYDRAULIC CONTINUITY WITH THE SURFACE

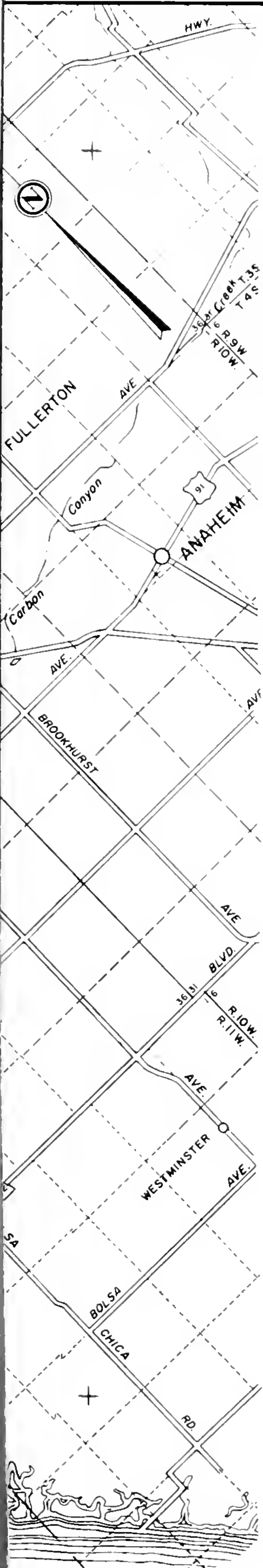
STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN CALIFORNIA DISTRICT

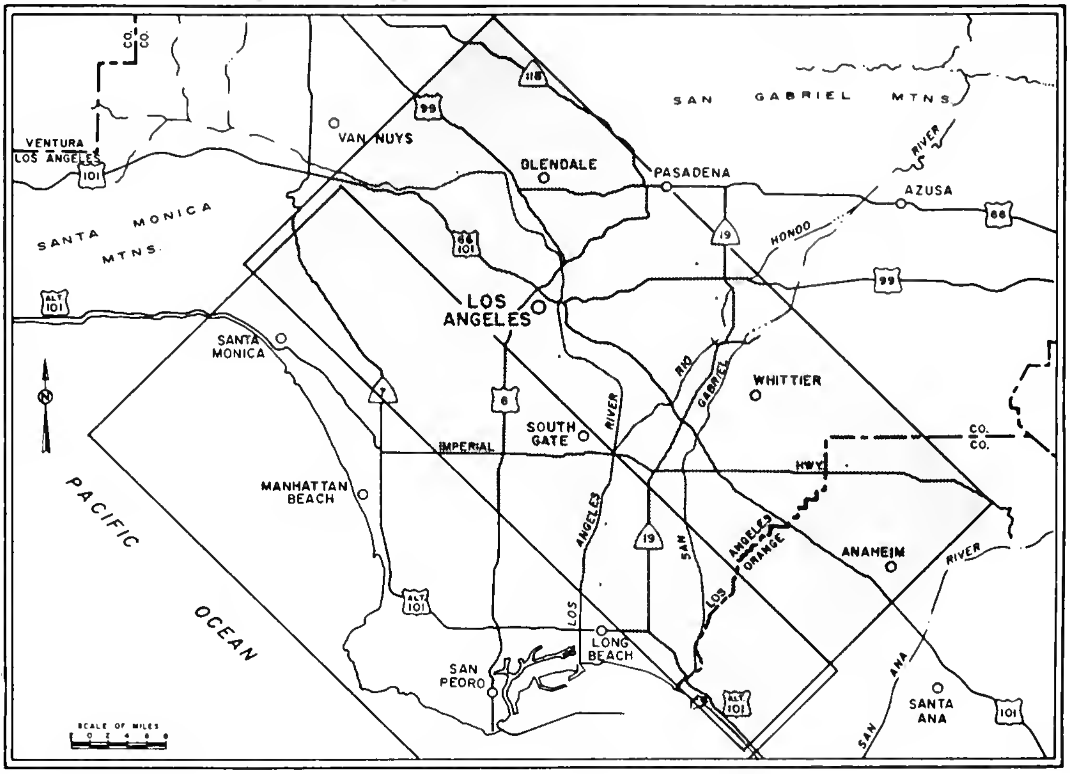
GROUND WATER GEOLOGY OF THE COASTAL PLAIN OF LOS ANGELES COUNTY

LINES OF EQUAL ELEVATION ON THE BASE OF THE GASPUR, BALLONA, ARTESIA, AND EXPOSITION AQUIFERS

SCALE OF MILES
1 0 1 2 3

1961





LOCATION MAP

LEGEND

SURFACE FEATURES

- Qal — RECENT ALLUVIUM
- Qpu — UPPER PLEISTOCENE DEPOSITS
- LOWER PLEISTOCENE DEPOSITS
- NONWATER-BEARING ROCKS

SUBSURFACE FEATURES

- BOUNDARY OF AQUIFERS (DASHED WHERE LOCATION IS APPROXIMATE)
- —60— LINES OF EQUAL ELEVATION ON THE BASE OF THE GASPUR, BALLONA, ARTESIA, AND EXPOSITION AQUIFERS (DASHED WHERE CONTROL IS POOR)
- FAULT (DASHED WHERE APPROXIMATELY LOCATED)
- GASPUR AQUIFER
- BALLONA AQUIFER
- ARTESIA AQUIFER
- EXPOSITION AQUIFER
- KNOWN AREAS WHERE AQUIFERS ARE IN HYDRAULIC CONTINUITY WITH THE SURFACE

STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN CALIFORNIA DISTRICT

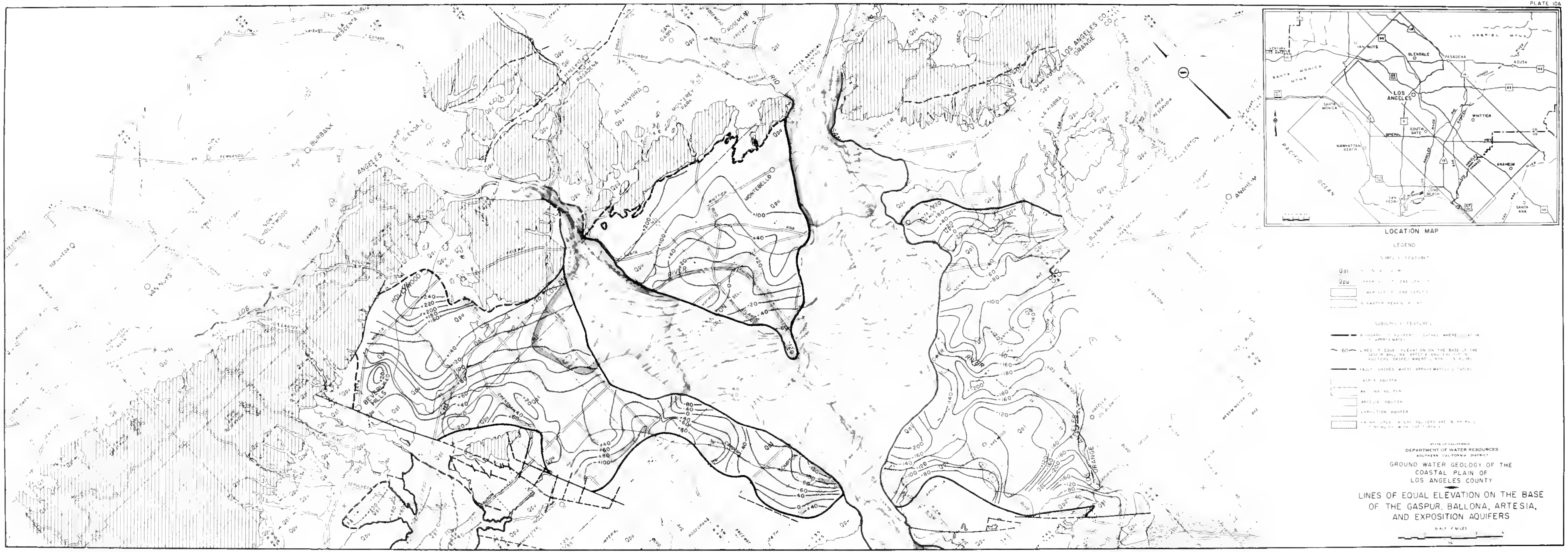
GROUND WATER GEOLOGY OF THE COASTAL PLAIN OF LOS ANGELES COUNTY

LINES OF EQUAL ELEVATION ON THE BASE OF THE GASPUR, BALLONA, ARTESIA, AND EXPOSITION AQUIFERS

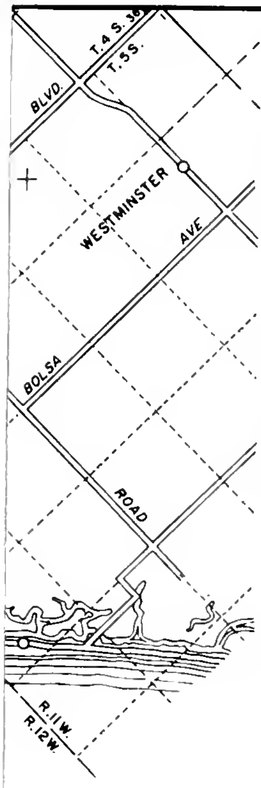
SCALE OF MILES
1 0 1 2 3

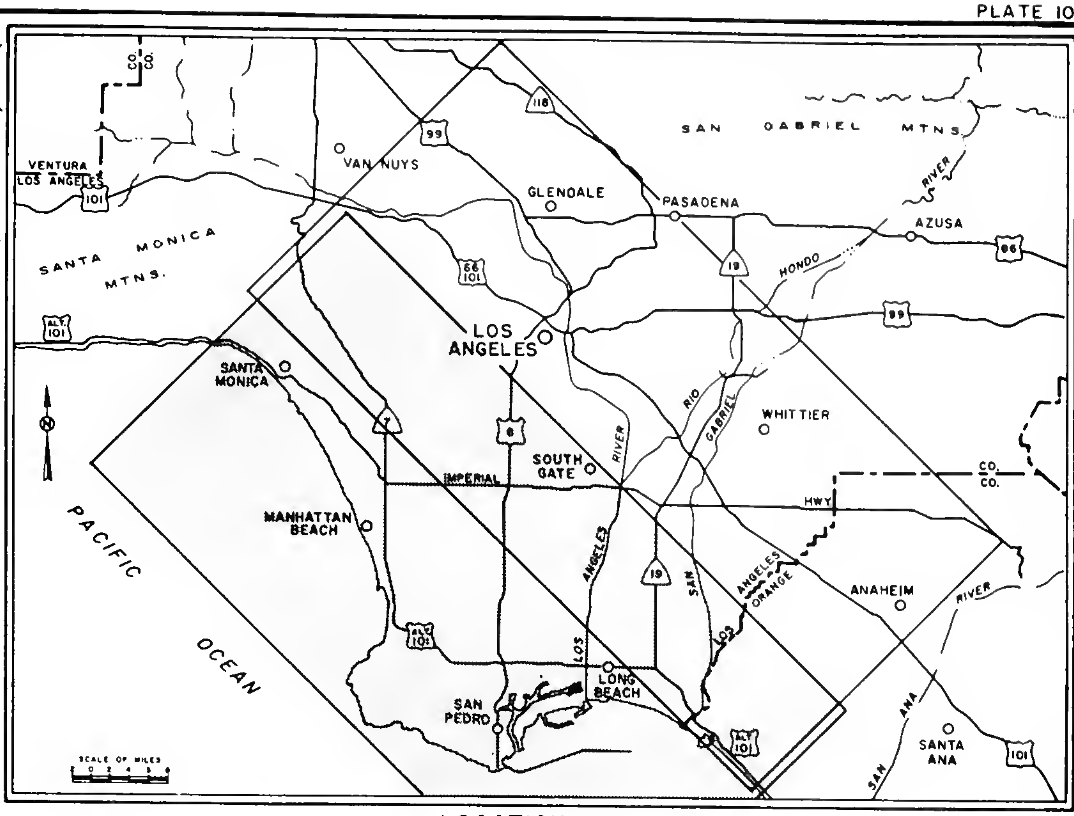
1961

PLATE 10A



LOCATION MAP
LEGEND
STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN CALIFORNIA DISTRICT
GROUND WATER GEOLOGY OF THE
COASTAL PLAIN OF
LOS ANGELES COUNTY
LINES OF EQUAL ELEVATION ON THE BASE
OF THE GASPUR, BALLONA, ARTESIA,
AND EXPOSITION AQUIFERS
SCALE IN MILES
PACIFIC OCEAN
LOS ANGELES
BURBANK
GLENDALE
ALHAMBRA
MONTEBELLO
WHITTIER
ANAHEIM
BEVERLY HILLS
VAN NUYS





LOCATION MAP

LEGEND

SURFACE FEATURES

Qal RECENT ALLUVIUM

Qpu UPPER PLEISTOCENE DEPOSITS

LOWER PLEISTOCENE DEPOSITS

NONWATER-BEARING ROCKS

SUBSURFACE FEATURES

BOUNDARY OF AQUIFERS (DASHED WHERE LOCATION IS APPROXIMATE)

-60- LINES OF EQUAL ELEVATION ON THE BASE OF THE GASPUR, BALLONA, ARTESIA, AND EXPOSITION AQUIFERS (DASHED WHERE CONTROL IS POOR)

FAULT (DASHED WHERE APPROXIMATELY LOCATED)

GASPUR AQUIFER

BALLONA AQUIFER

ARTESIA AQUIFER

EXPOSITION AQUIFER

KNOWN AREAS WHERE AQUIFERS ARE IN HYDRAULIC CONTINUITY WITH THE SURFACE

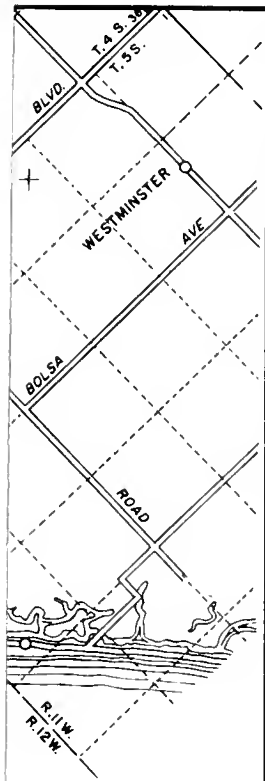
STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN CALIFORNIA DISTRICT

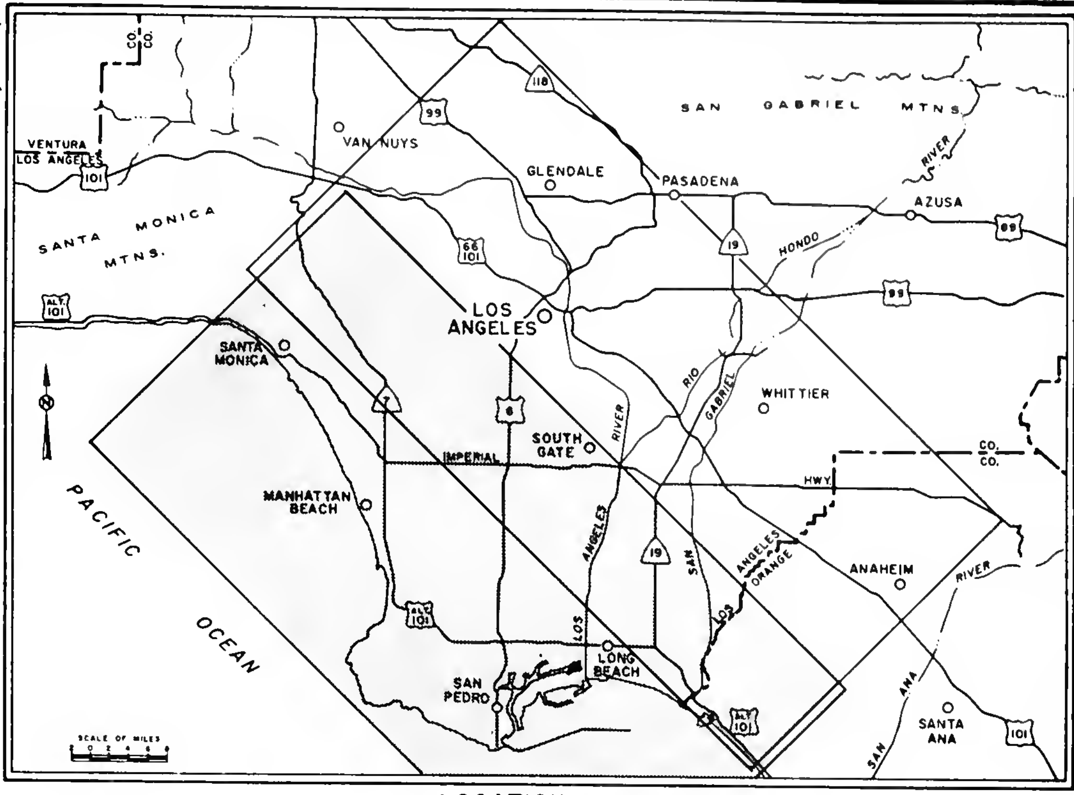
GROUND WATER GEOLOGY OF THE COASTAL PLAIN OF LOS ANGELES COUNTY

LINES OF EQUAL ELEVATION ON THE BASE OF THE GASPUR, BALLONA, ARTESIA, AND EXPOSITION AQUIFERS

SCALE OF MILES
1 0 1 2 3

1961





LOCATION MAP

LEGEND

SURFACE FEATURES

Qal	RECENT ALLUVIUM
Qpu	UPPER PLEISTOCENE DEPOSITS
	LOWER PLEISTOCENE DEPOSITS
	NONWATER-BEARING ROCKS

SUBSURFACE FEATURES

	BOUNDARY OF AQUIFERS (DASHED WHERE LOCATION IS APPROXIMATE)
-60-	LINES OF EQUAL ELEVATION ON THE BASE OF THE GASPUR, BALLONA, ARTESIA, AND EXPOSITION AQUIFERS (DASHED WHERE CONTROL IS POOR)
	FAULT (DASHED WHERE APPROXIMATELY LOCATED)
	GASPUR AQUIFER
	BALLONA AQUIFER
	ARTESIA AQUIFER
	EXPOSITION AQUIFER
	KNOWN AREAS WHERE AQUIFERS ARE IN HYDRAULIC CONTINUITY WITH THE SURFACE

STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN CALIFORNIA DISTRICT

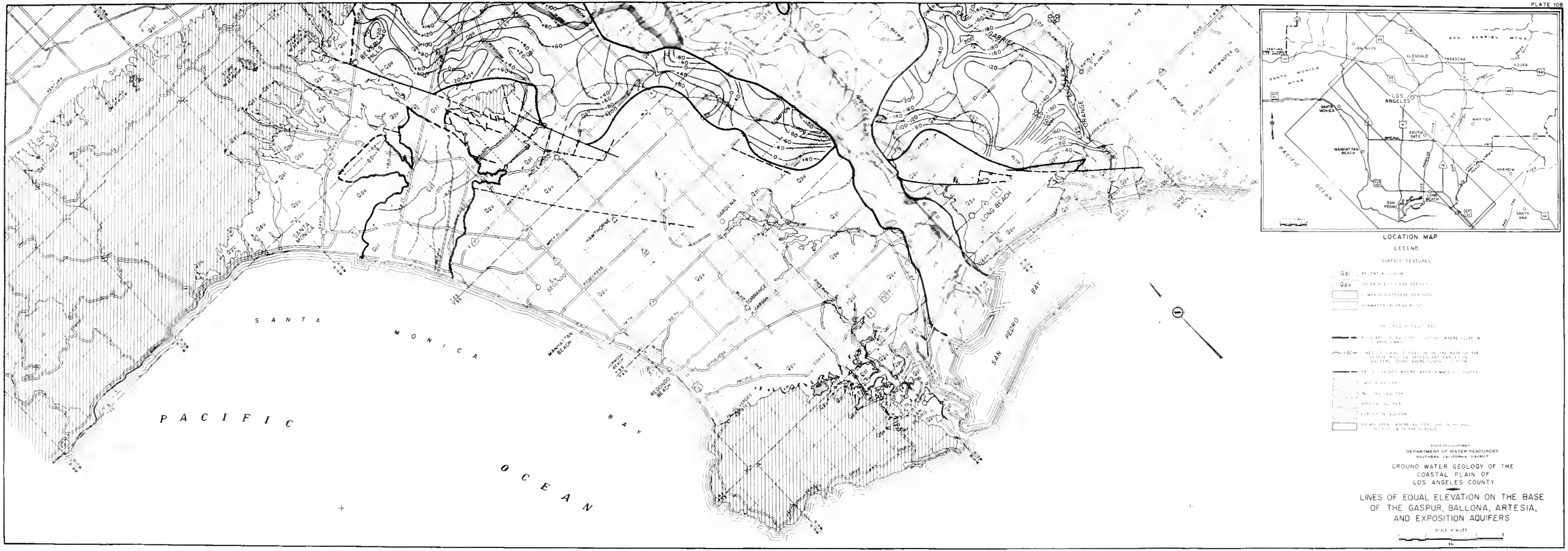
GROUND WATER GEOLOGY OF THE COASTAL PLAIN OF LOS ANGELES COUNTY

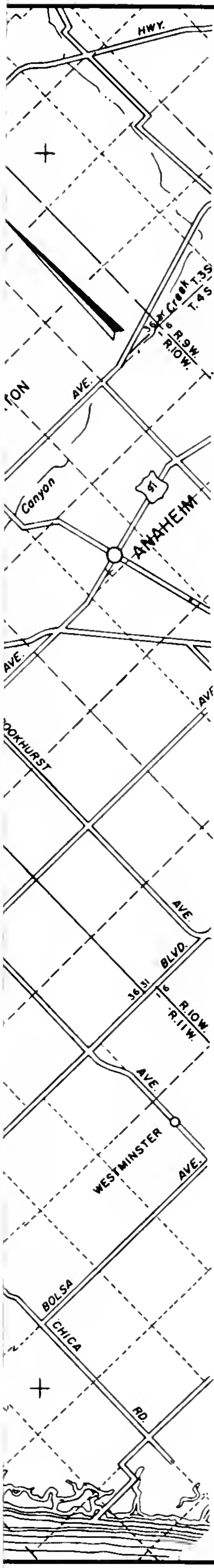
LINES OF EQUAL ELEVATION ON THE BASE OF THE GASPUR, BALLONA, ARTESIA, AND EXPOSITION AQUIFERS

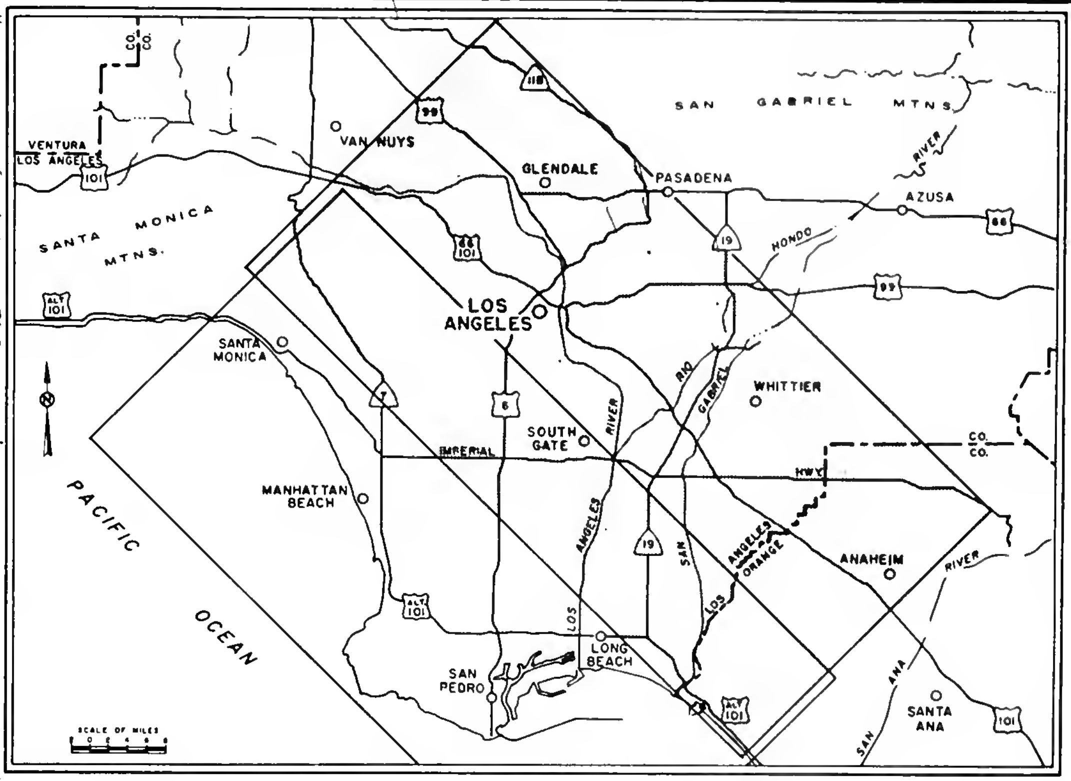
SCALE OF MILES
1 0 1 2 3

1961

PLATE 10B


PACIFIC OCEAN
SANTA MONICA BAY
SAN PEDRO BAY
SANTA MONICA
BEVERLY HILLS
INGLEWOOD
HAWTHORNE
EL SEGUNDO
MANHATTAN BEACH
HERMOSA BEACH
REDONDO BEACH
GARDENA
TORRANCE
LONG BEACH
SAN PEDRO
SOUTH GATE
Qal
Qpu
LOCATION MAP
LOS ANGELES
GLENDALE
PASADENA
VAN NUYS
SANTA MONICA MTNS
SAN GABRIEL MTNS
WHITTIER
ANAHEIM
SANTA ANA
AZUSA
MANHATTAN BEACH
LEGEND
SURFACE FEATURES
STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN CALIFORNIA DISTRICT
GROUND WATER GEOLOGY OF THE
COASTAL PLAIN OF
LOS ANGELES COUNTY
LINES OF EQUAL ELEVATION ON THE BASE
OF THE GASPUR, BALLONA, ARTESIA,
AND EXPOSITION AQUIFERS
SCALE IN MILES





LOCATION MAP

LEGEND

SURFACE FEATURES

Qal	RECENT ALLUVIUM
Qpu	UPPER PLEISTOCENE DEPOSITS
	LOWER PLEISTOCENE DEPOSITS
	NONWATER-BEARING ROCKS

SUBSURFACE FEATURES

BOUNDARY OF AQUIFERS (DASHED WHERE LOCATION IS APPROXIMATE)

80 — LINES OF EQUAL THICKNESS OF THE GASPUR BALLONA, ARTESIA, AND EXPOSITION AQUIFERS (DASHED WHERE CONTROL IS POOR)

FAULT (DASHED WHERE APPROXIMATELY LOCATED)

GASPUR AQUIFER

BALLONA AQUIFER

ARTESIA AQUIFER

EXPOSITION AQUIFER

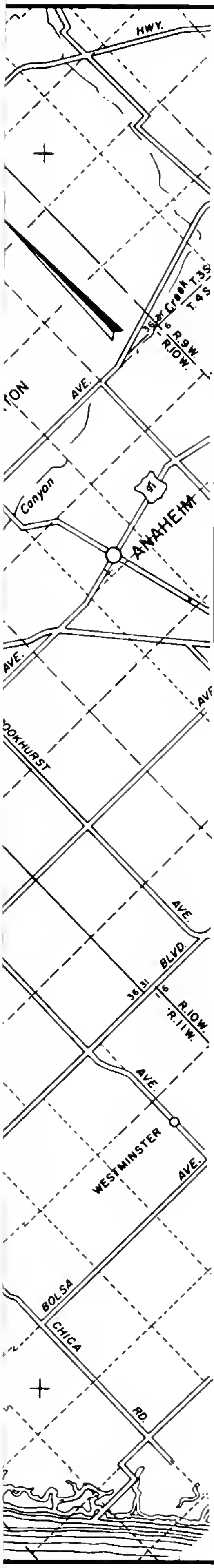
STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN CALIFORNIA DISTRICT

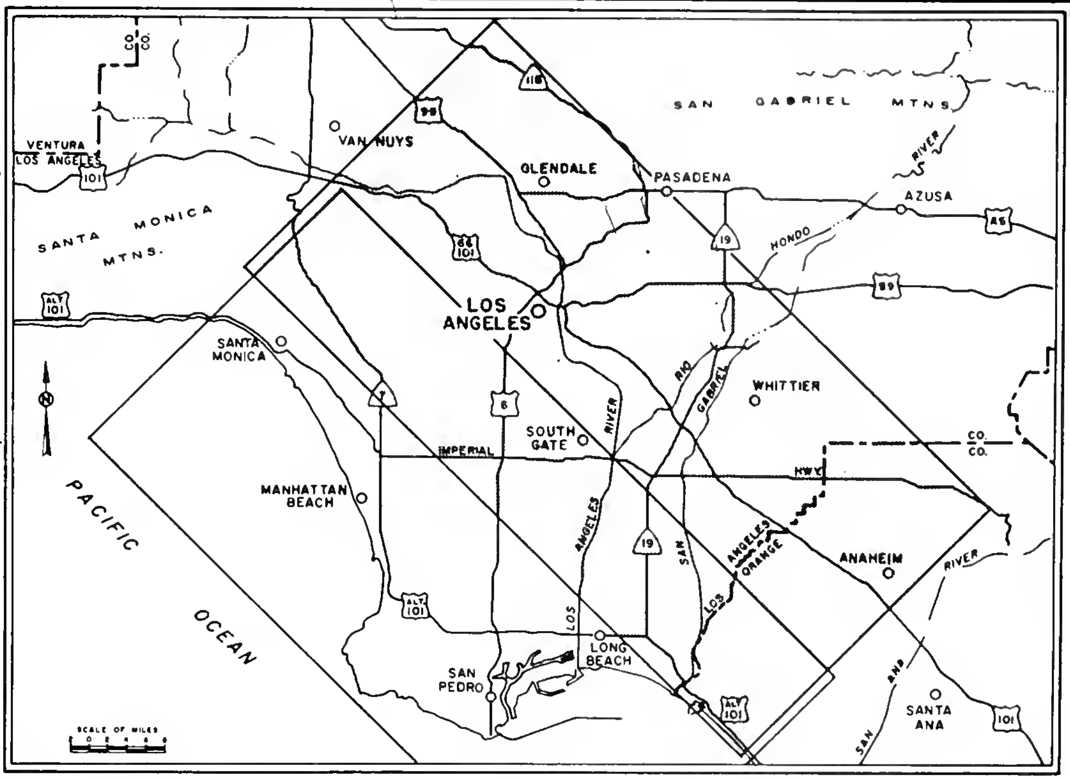
GROUND WATER GEOLOGY OF THE COASTAL PLAIN OF LOS ANGELES COUNTY

LINES OF EQUAL THICKNESS OF THE GASPUR, BALLONA, ARTESIA, AND EXPOSITION AQUIFERS

SCALE OF MILES
1 0 1 2 3

1961





LOCATION MAP

LEGEND

SURFACE FEATURES

- Qal — RECENT ALLUVIUM
- Qpu — UPPER PLEISTOCENE DEPOSITS
- LOWER PLEISTOCENE DEPOSITS
- NONWATER-BEARING ROCKS

SUBSURFACE FEATURES

- BOUNDARY OF AQUIFERS (DASHED WHERE LOCATION IS APPROXIMATE)
- 80 — LINES OF EQUAL THICKNESS OF THE GASPUR BALLONA, ARTESIA, AND EXPOSITION AQUIFERS (DASHED WHERE CONTROL IS POOR)
- FAULT (DASHED WHERE APPROXIMATELY LOCATED)
- GASPUR AQUIFER
- BALLONA AQUIFER
- ARTESIA AQUIFER
- EXPOSITION AQUIFER

STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN CALIFORNIA DISTRICT

GROUND WATER GEOLOGY OF THE COASTAL PLAIN OF LOS ANGELES COUNTY

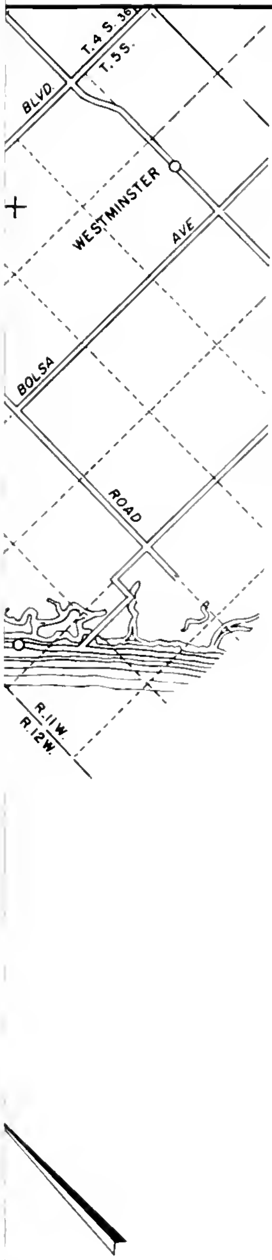
LINES OF EQUAL THICKNESS OF THE GASPUR, BALLONA, ARTESIA, AND EXPOSITION AQUIFERS

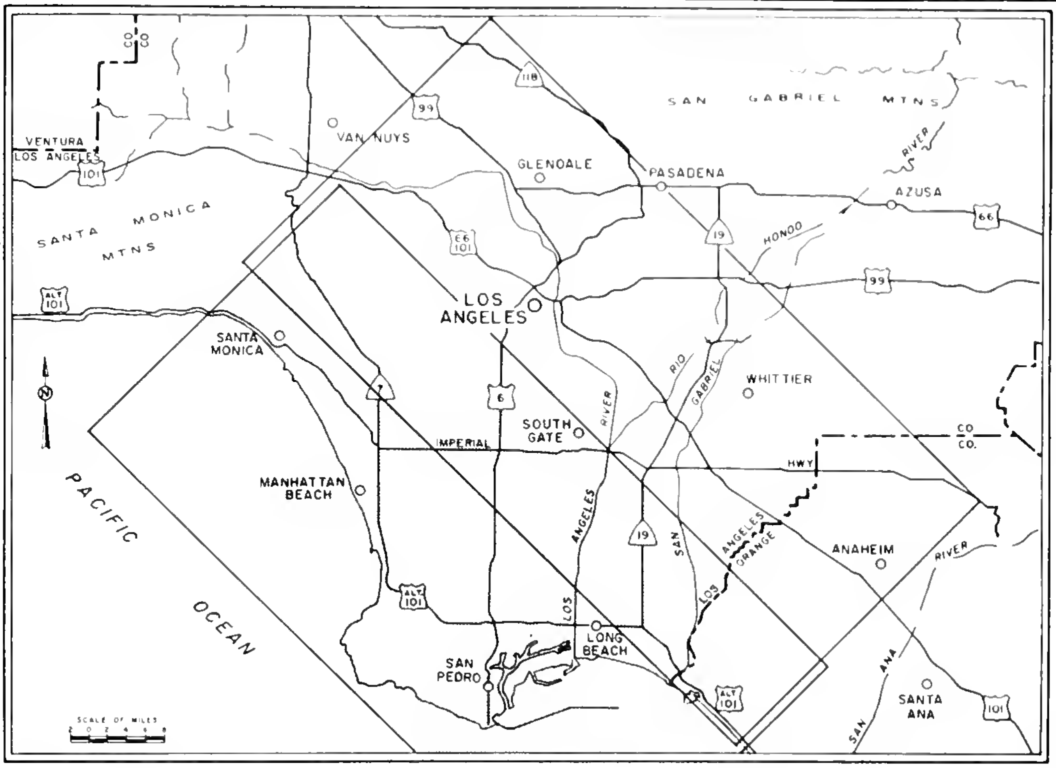
SCALE OF MILES

1 0 1 2 3

1961


LOCATION MAP
LEGEND
SURFACE FEATURES
Qal
Qpu
SUBSURFACE FEATURES
GASPUR AQUIFER
BALLONA AQUIFER
ARTESIA AQUIFER
EXPOSITION AQUIFER
STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN CALIFORNIA DISTRICT
GROUND WATER GEOLOGY OF THE
COASTAL PLAIN OF
LOS ANGELES COUNTY
LINES OF EQUAL THICKNESS
OF THE GASPUR, BALLONA, ARTESIA,
AND EXPOSITION AQUIFERS
SCALE OF MILES
1961





LOCATION MAP

LEGEND

SURFACE FEATURES

Qal	RECENT ALLUVIUM
Qpu	UPPER PLEISTOCENE DEPOSITS
	LOWER PLEISTOCENE DEPOSITS
	NONWATER-BEARING ROCKS

SUBSURFACE FEATURES

	BOUNDARY OF AQUIFERS (DASHED WHERE LOCATION IS APPROXIMATE)
80	LINES OF EQUAL THICKNESS OF THE GASPUR, BALLONA, ARTESIA, AND EXPOSITION AQUIFERS (DASHED WHERE CONTROL IS POOR)
	FAULT (DASHED WHERE APPROXIMATELY LOCATED)
	GASPUR AQUIFER
	BALLONA AQUIFER
	ARTESIA AQUIFER
	EXPOSITION AQUIFER

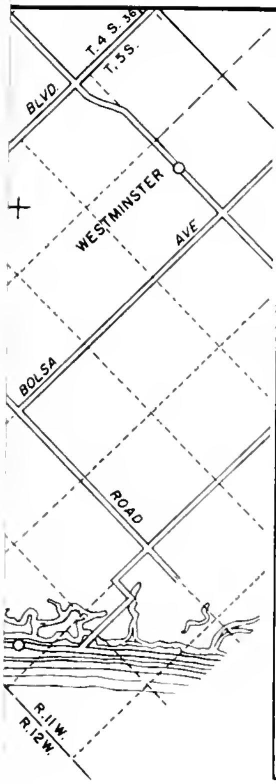
STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN CALIFORNIA DISTRICT

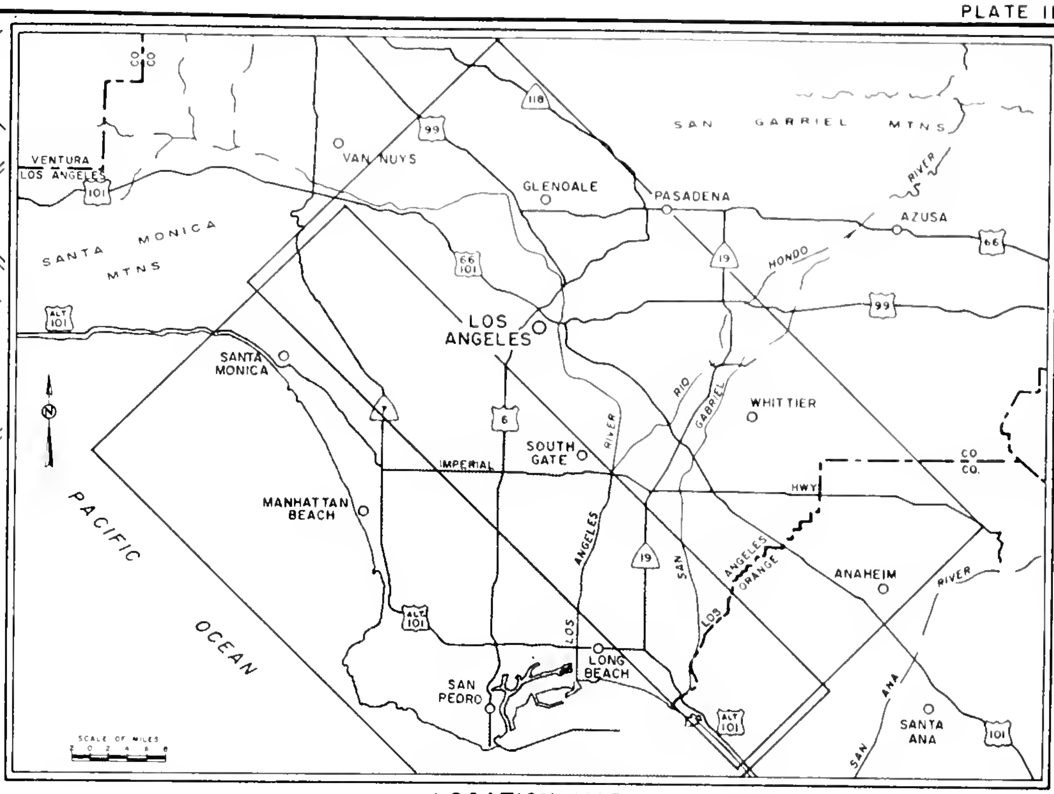
GROUND WATER GEOLOGY OF THE COASTAL PLAIN OF LOS ANGELES COUNTY

LINES OF EQUAL THICKNESS OF THE GASPUR, BALLONA, ARTESIA, AND EXPOSITION AQUIFERS

SCALE OF MILES
1 0 1 2 3

1961





LOCATION MAP

LEGEND

SURFACE FEATURES

Qal	RECENT ALLUVIUM
Qpu	UPPER PLEISTOCENE DEPOSITS
	LOWER PLEISTOCENE DEPOSITS
	NONWATER-BEARING ROCKS

SUBSURFACE FEATURES

	BOUNDARY OF AQUIFERS (DASHED WHERE LOCATION IS APPROXIMATE)
80	LINES OF EQUAL THICKNESS OF THE GASPUR, BALLONA, ARTESIA, AND EXPOSITION AQUIFERS (DASHED WHERE CONTROL IS POOR)
	FAULT (DASHED WHERE APPROXIMATELY LOCATED)
	GASPUR AQUIFER
	BALLONA AQUIFER
	ARTESIA AQUIFER
	EXPOSITION AQUIFER

STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN CALIFORNIA DISTRICT

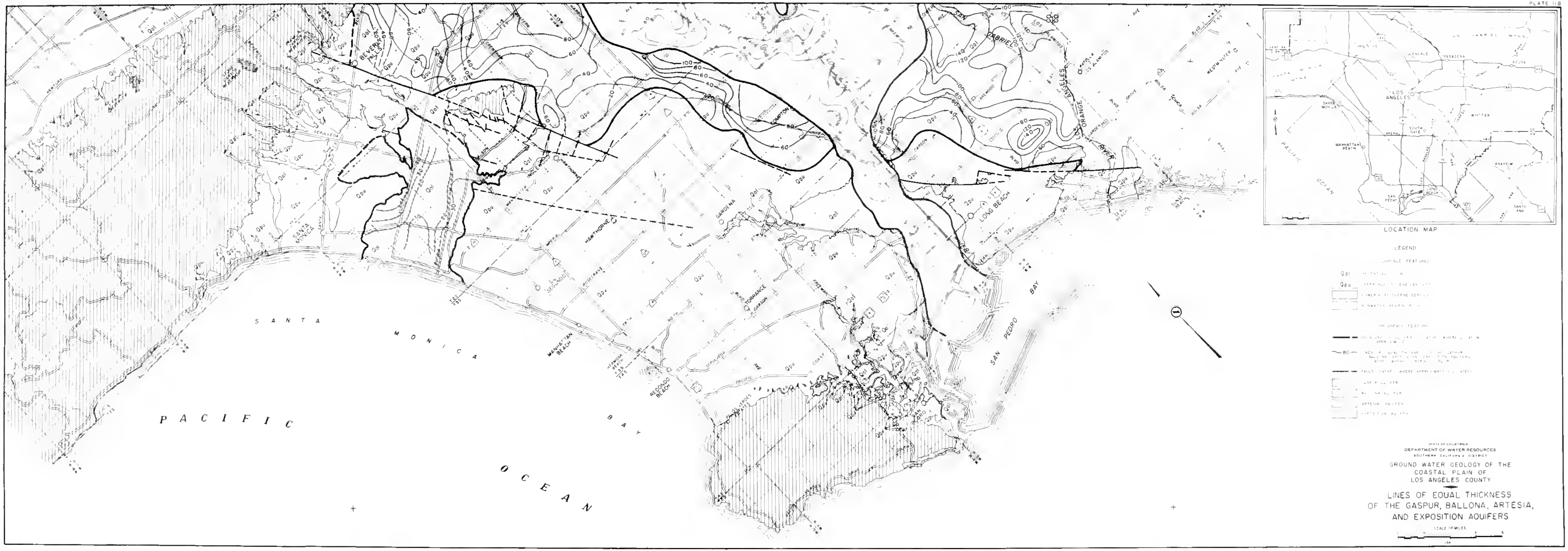
GROUND WATER GEOLOGY OF THE COASTAL PLAIN OF LOS ANGELES COUNTY

LINES OF EQUAL THICKNESS OF THE GASPUR, BALLONA, ARTESIA, AND EXPOSITION AQUIFERS

SCALE OF MILES

1 0 1 2 3

1961

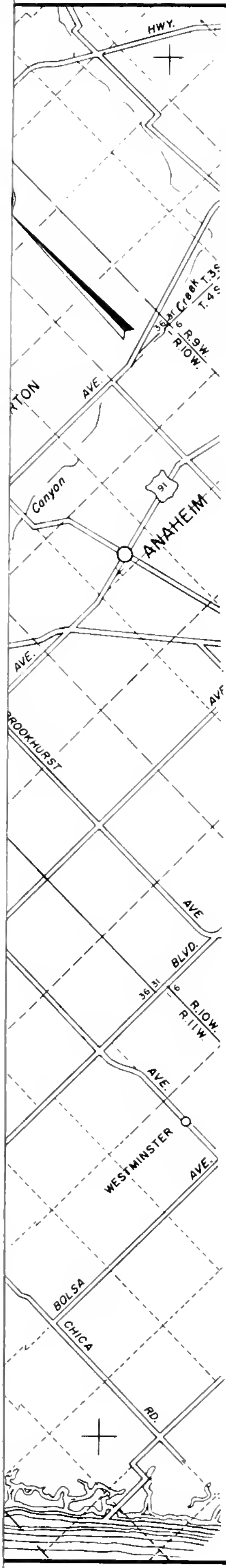


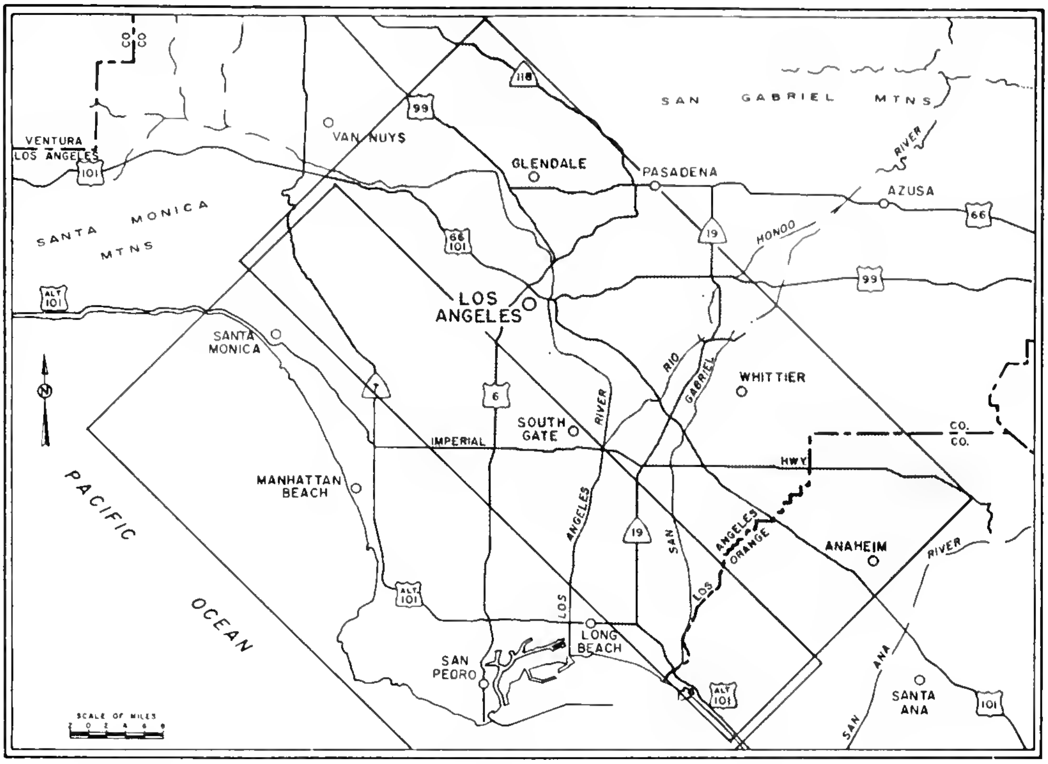
STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN CALIFORNIA DISTRICT

GROUND WATER GEOLOGY OF THE COASTAL PLAIN OF LOS ANGELES COUNTY

LINES OF EQUAL THICKNESS OF THE GASPUR, BALLONA, ARTESIA, AND EXPOSITION AQUIFERS

SCALE OF MILES





LOCATION MAP

LEGEND

SURFACE FEATURES

Qal	RECENT ALLUVIUM
Qpu	UPPER PLEISTOCENE DEPOSITS
	LOWER PLEISTOCENE DEPOSITS
	NONWATER-BEARING ROCKS

SUBSURFACE FEATURES

	BOUNDARY OF AQUIFERS (DASHED WHERE LOCATION IS APPROXIMATE)
-50	LINES OF EQUAL ELEVATION ON THE BASE OF THE GAGE AND GARDENA AQUIFERS (DASHED WHERE CONTROL IS POOR)
	FAULT (DASHED WHERE APPROXIMATELY LOCATED)
	GAGE AQUIFER
	GARDENA AQUIFER
	KNOWN AREAS WHERE THE GAGE AND GARDENA AQUIFERS ARE MERGED WITH THE OVERLYING AQUIFER OR WITH THE SURFACE

STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN CALIFORNIA DISTRICT

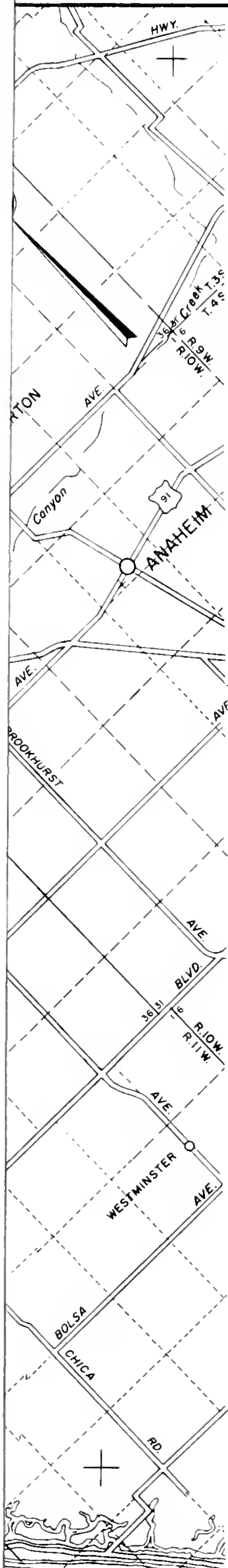
GROUND WATER GEOLOGY OF THE COASTAL PLAIN OF LOS ANGELES COUNTY

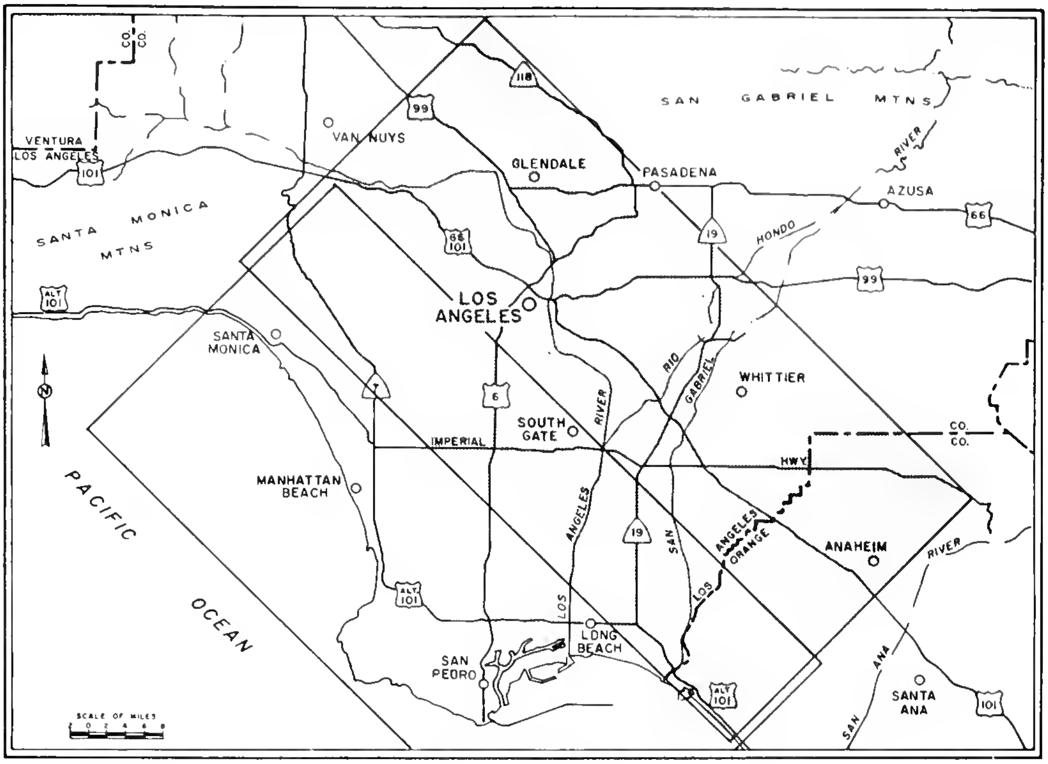
LINES OF EQUAL ELEVATION ON THE BASE OF THE GAGE AND GARDENA AQUIFERS

SCALE OF MILES

1 0 1 2 3

1961





LOCATION MAP

LEGEND

SURFACE FEATURES

- Qal — RECENT ALLUVIUM
- Qpu — UPPER PLEISTOCENE DEPOSITS
- LOWER PLEISTOCENE DEPOSITS
- NONWATER-BEARING ROCKS

SUBSURFACE FEATURES

- BOUNDARY OF AQUIFERS (DASHED WHERE LOCATION IS APPROXIMATE)
- -50- LINES OF EQUAL ELEVATION ON THE BASE OF THE GAGE AND GARDENA AQUIFERS (DASHED WHERE CONTROL IS POOR)
- FAULT (DASHED WHERE APPROXIMATELY LOCATED)
- GAGE AQUIFER
- GARDENA AQUIFER
- KNOWN AREAS WHERE THE GAGE AND GARDENA AQUIFERS ARE MERGED WITH THE OVERLYING AQUIFER OR WITH THE SURFACE

STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN CALIFORNIA DISTRICT

GROUND WATER GEOLOGY OF THE
COASTAL PLAIN OF
LOS ANGELES COUNTY

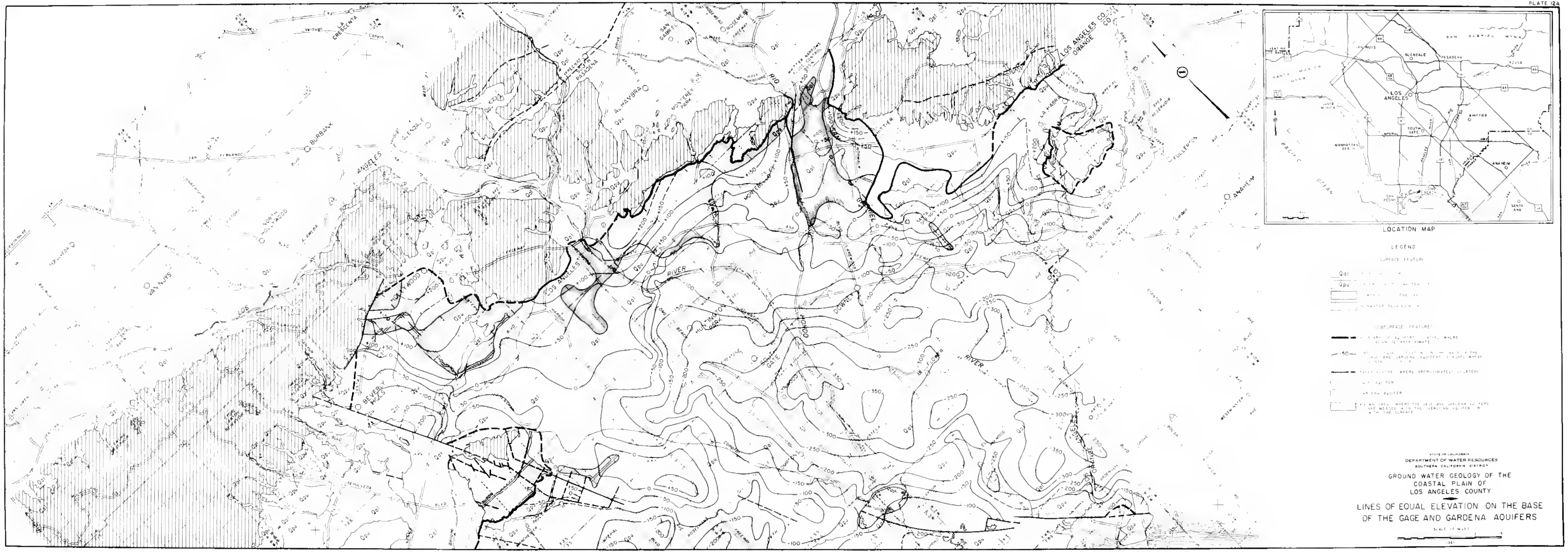
LINES OF EQUAL ELEVATION ON THE BASE OF THE GAGE AND GARDENA AQUIFERS

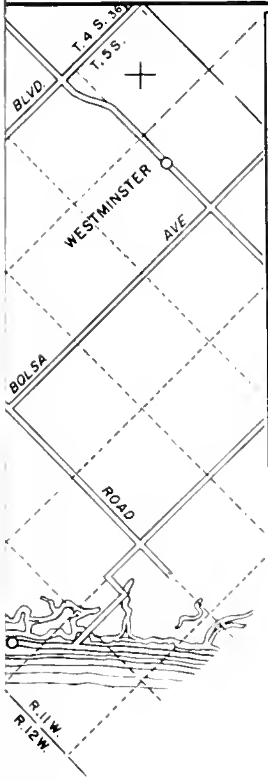
SCALE OF MILES

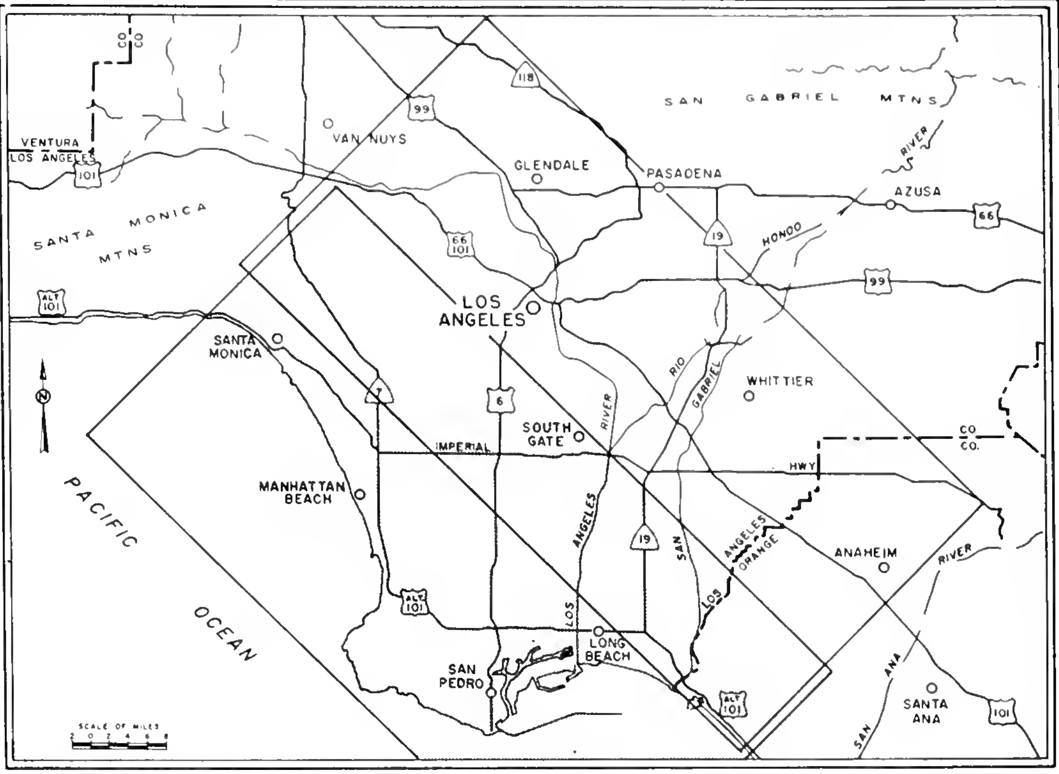
1 0 1 2 3

1961

PLATE 12A


LOCATION MAP
LEGEND
LOS ANGELES CO.
ORANGE CO.
RIO HONDO
LOS ANGELES RIVER
SAN GABRIEL RIVER
BURBANK
GLENDALE
PASADENA
ALHAMBRA
MONTEREY PARK
ROSEMEAD
SAN GABRIEL
WHITTIER
LA HABRA
FULLERTON
ANAHEIM
BUENA PARK
DOWNEY
SOUTH GATE
HUNTINGTON PARK
BEVERLY HILLS
HOLLYWOOD
NORTH HOLLYWOOD
VAN NUYS
LOS ANGELES
SANTA MONICA MTNS
PACIFIC OCEAN
STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN CALIFORNIA DISTRICT
GROUND WATER GEOLOGY OF THE
COASTAL PLAIN OF
LOS ANGELES COUNTY
LINES OF EQUAL ELEVATION ON THE BASE
OF THE GAGE AND GARDENA AQUIFERS
1961





LOCATION MAP

LEGEND

SURFACE FEATURES

Qal	RECENT ALLUVIUM
Qpu	UPPER PLEISTOCENE DEPOSITS
	LOWER PLEISTOCENE DEPOSITS
	NONWATER-BEARING ROCKS

SUBSURFACE FEATURES

	BOUNDARY OF AQUIFERS (DASHED WHERE LOCATION IS APPROXIMATE)
-50-	LINES OF EQUAL ELEVATION ON THE BASE OF THE GAGE AND GARDENA AQUIFERS (DASHED WHERE CONTROL IS POOR)
	FAULT (DASHED WHERE APPROXIMATELY LOCATED)
	GAGE AQUIFER
	GARDENA AQUIFER
	KNOWN AREAS WHERE THE GAGE AND GARDENA AQUIFERS ARE MERGED WITH THE OVERLYING AQUIFER OR WITH THE SURFACE

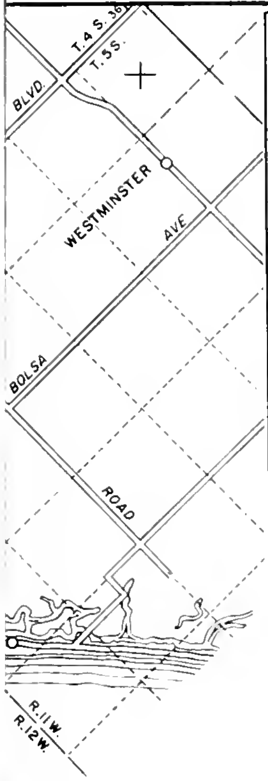
STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN CALIFORNIA DISTRICT

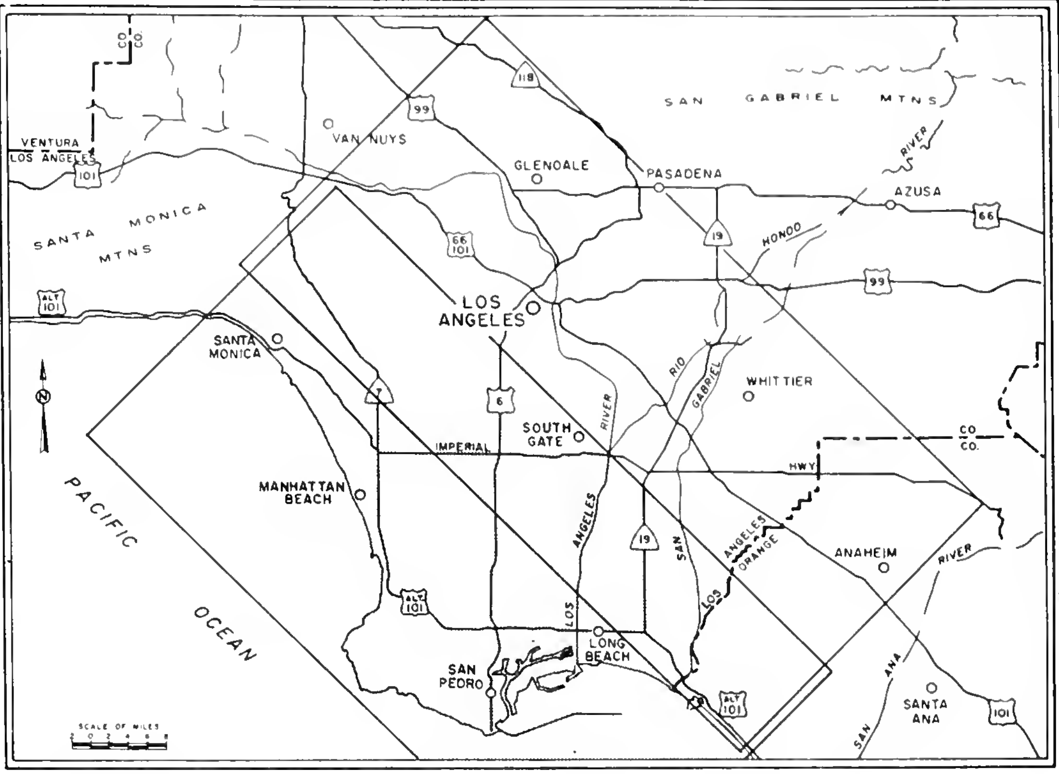
GROUND WATER GEOLOGY OF THE COASTAL PLAIN OF LOS ANGELES COUNTY

LINES OF EQUAL ELEVATION ON THE BASE OF THE GAGE AND GARDENA AQUIFERS

SCALE OF MILES
1 0 1 2 3

1961





LOCATION MAP

LEGEND

SURFACE FEATURES

Qal	RECENT ALLUVIUM
Qpu	UPPER PLEISTOCENE DEPOSITS
	LOWER PLEISTOCENE DEPOSITS
	NONWATER-BEARING ROCKS

SUBSURFACE FEATURES

	BOUNDARY OF AQUIFERS (DASHED WHERE LOCATION IS APPROXIMATE)
-50-	LINES OF EQUAL ELEVATION ON THE BASE OF THE GAGE AND GARDENA AQUIFERS (DASHED WHERE CONTROL IS POOR)
	FAULT (DASHED WHERE APPROXIMATELY LOCATED)
	GAGE AQUIFER
	GARDENA AQUIFER
	KNOWN AREAS WHERE THE GAGE AND GARDENA AQUIFERS ARE MERGED WITH THE OVERLYING AQUIFER OR WITH THE SURFACE

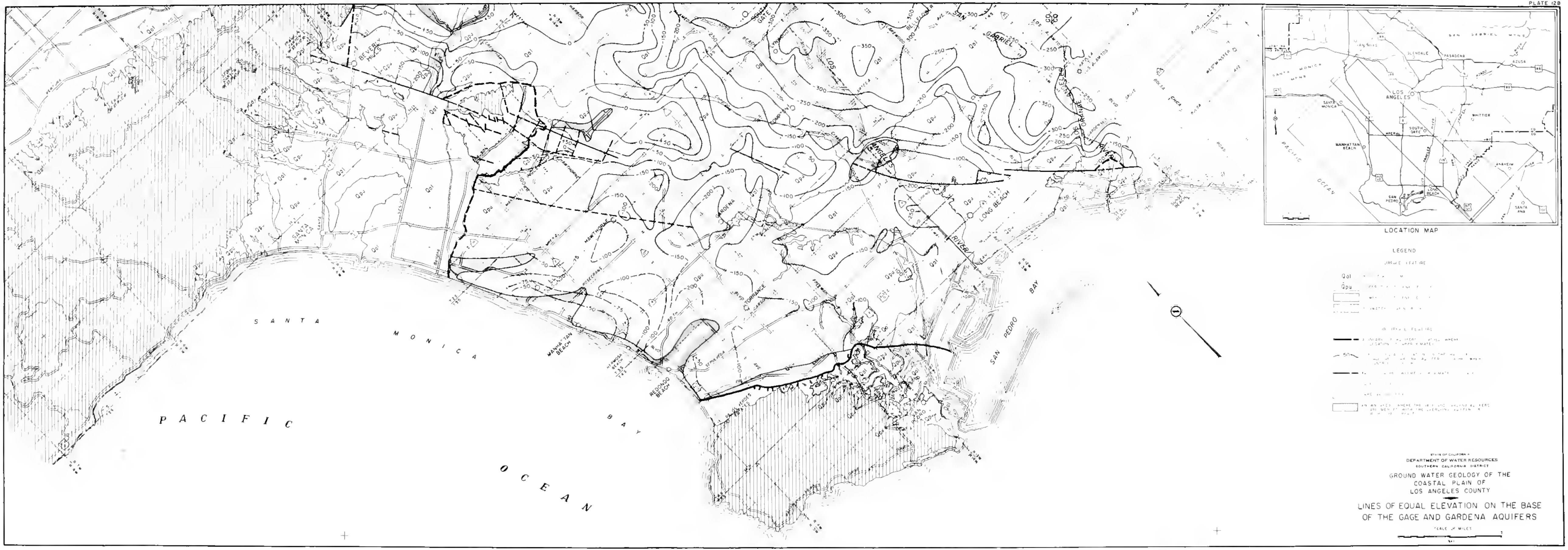
STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN CALIFORNIA DISTRICT

GROUND WATER GEOLOGY OF THE
COASTAL PLAIN OF
LOS ANGELES COUNTY

LINES OF EQUAL ELEVATION ON THE BASE OF THE GAGE AND GARDENA AQUIFERS

SCALE OF MILES
1 0 1 2 3

1961

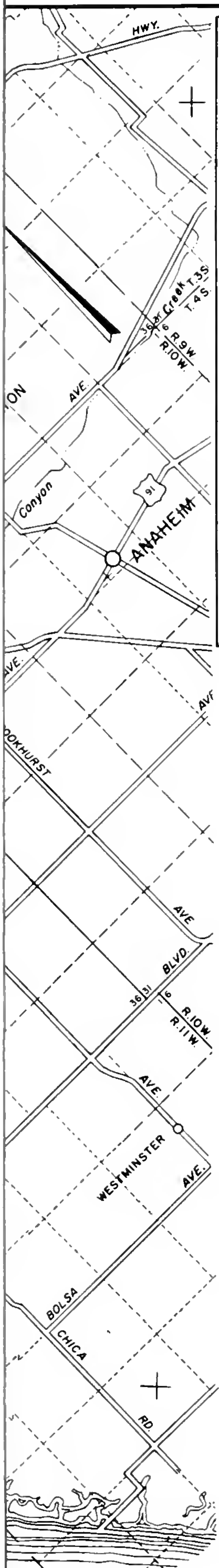


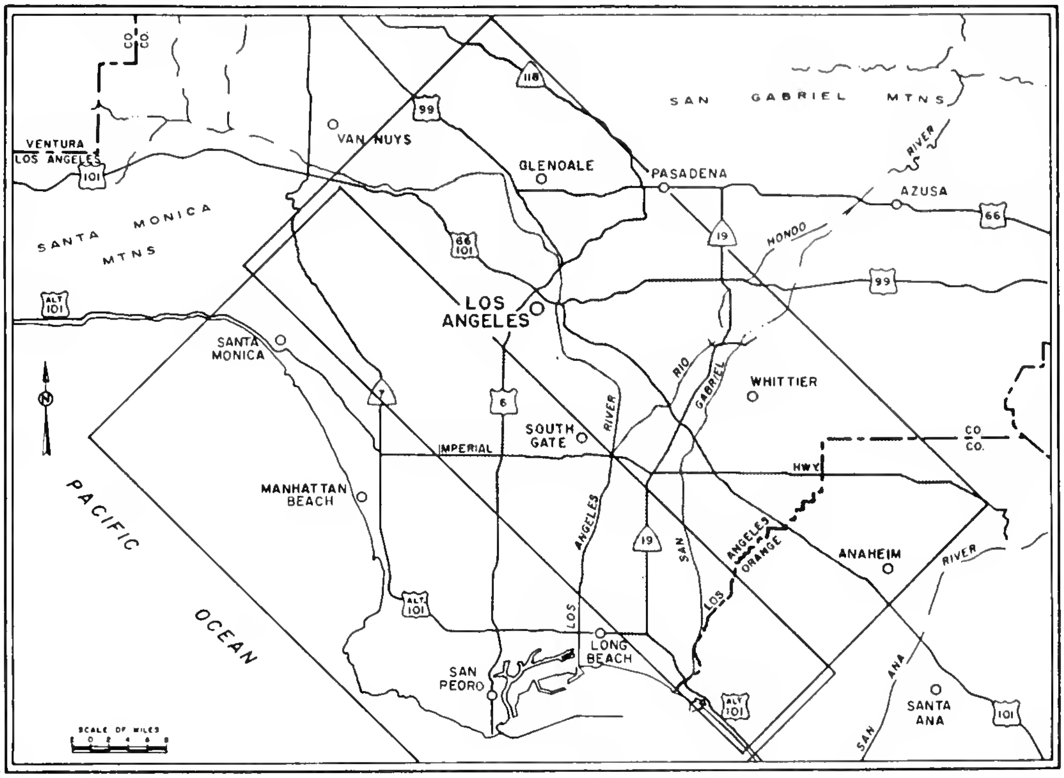
STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN CALIFORNIA DISTRICT

GROUND WATER GEOLOGY OF THE COASTAL PLAIN OF LOS ANGELES COUNTY

LINES OF EQUAL ELEVATION ON THE BASE OF THE GAGE AND GARDENA AQUIFERS

SCALE OF MILES





LOCATION MAP

LEGEND

SURFACE FEATURES

Qal	RECENT ALLUVIUM
Qpu	UPPER PLEISTOCENE DEPOSITS
	LOWER PLEISTOCENE DEPOSITS
	NONWATER-BEARING ROCKS

SUBSURFACE FEATURES

- BOUNDARY OF AQUIFERS (DASHED WHERE LOCATION IS APPROXIMATE)
- 60 — LINES OF EQUAL THICKNESS OF THE GAGE AND GARDENA AQUIFERS (DASHED WHERE CONTROL IS POOR)
- FAULT (DASHED WHERE APPROXIMATELY LOCATED)
- GAGE AQUIFER
- GARDENA AQUIFER

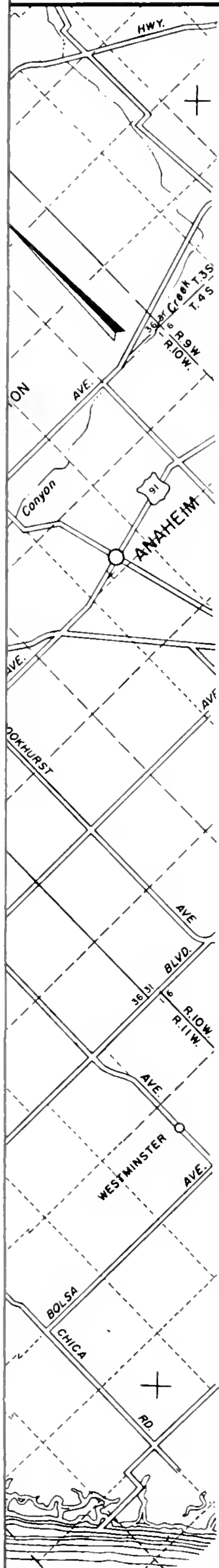
STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN CALIFORNIA DISTRICT

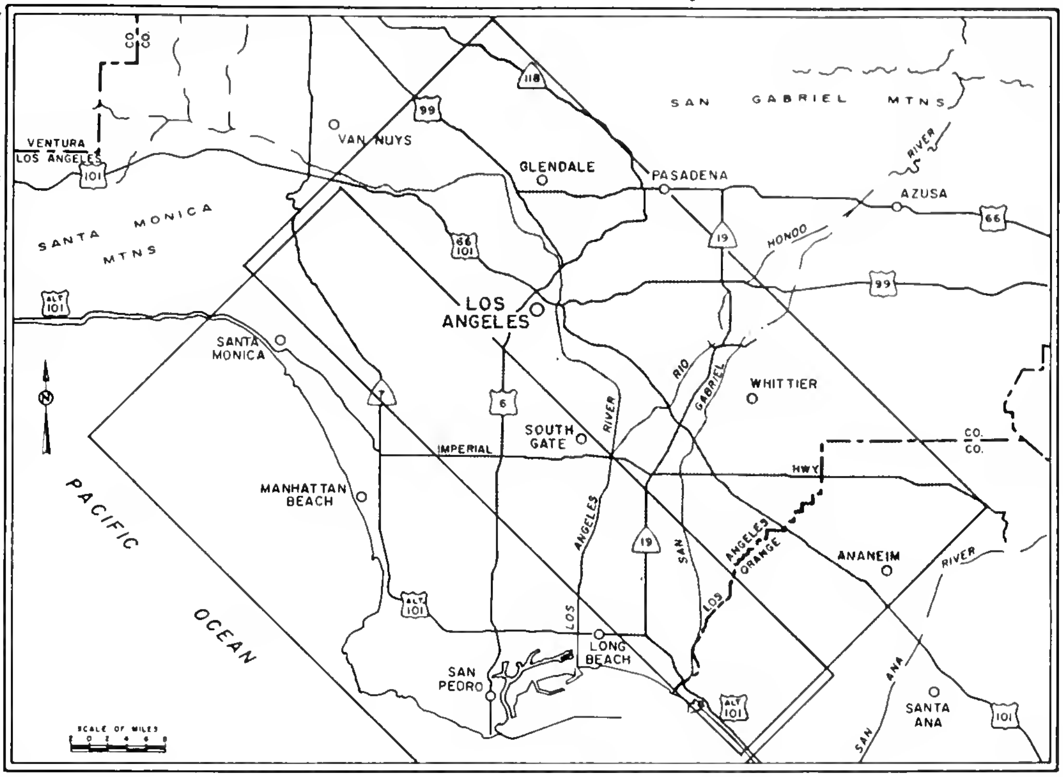
GROUND WATER GEOLOGY OF THE COASTAL PLAIN OF LOS ANGELES COUNTY

LINES OF EQUAL THICKNESS OF THE GAGE AND GARDENA AQUIFERS

SCALE OF MILES
1 0 1 2 3

1961





LOCATION MAP

LEGEND

SURFACE FEATURES

Qal	RECENT ALLUVIUM
Qpu	UPPER PLEISTOCENE DEPOSITS
	LOWER PLEISTOCENE DEPOSITS
	NONWATER-BEARING ROCKS

SUBSURFACE FEATURES

	BOUNDARY OF AQUIFERS (DASHED WHERE LOCATION IS APPROXIMATE)
60	LINES OF EQUAL THICKNESS OF THE GAGE AND GARDENA AQUIFERS (DASHED WHERE CONTROL IS POOR)
	FAULT (DASHED WHERE APPROXIMATELY LOCATED)
	GAGE AQUIFER
	GARDENA AQUIFER

STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN CALIFORNIA DISTRICT

GROUND WATER GEOLOGY OF THE COASTAL PLAIN OF LOS ANGELES COUNTY

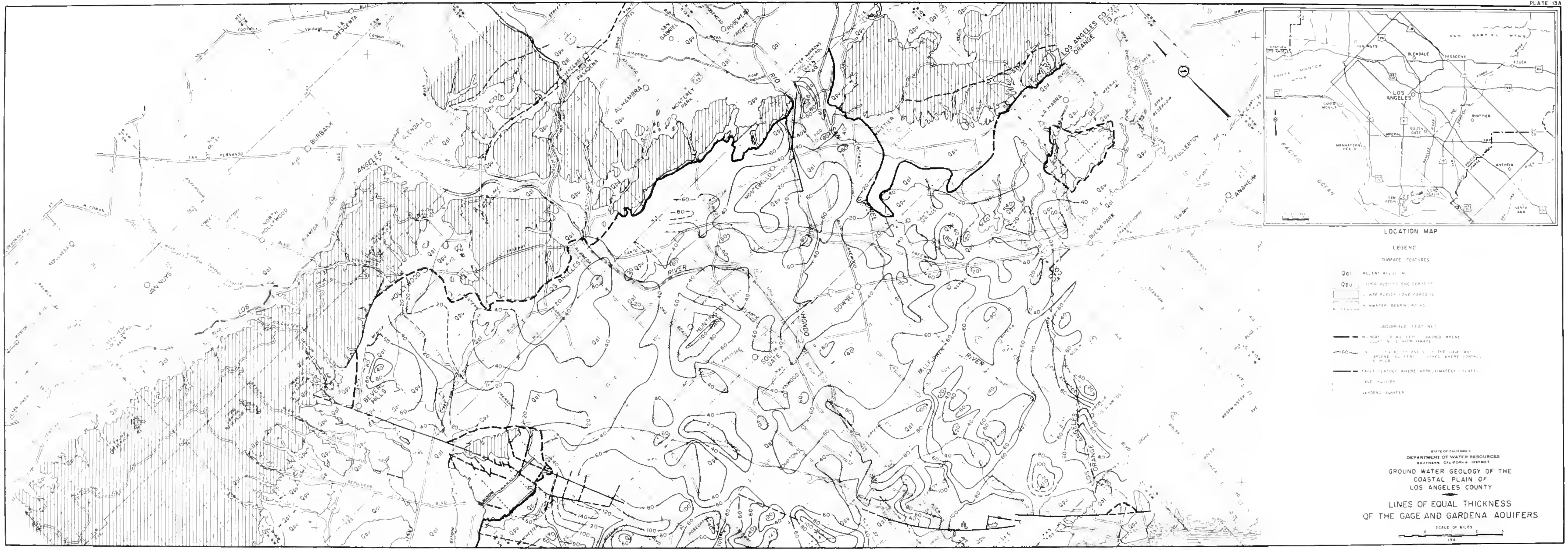
LINES OF EQUAL THICKNESS OF THE GAGE AND GARDENA AQUIFERS

SCALE OF MILES

1 0 1 2 3

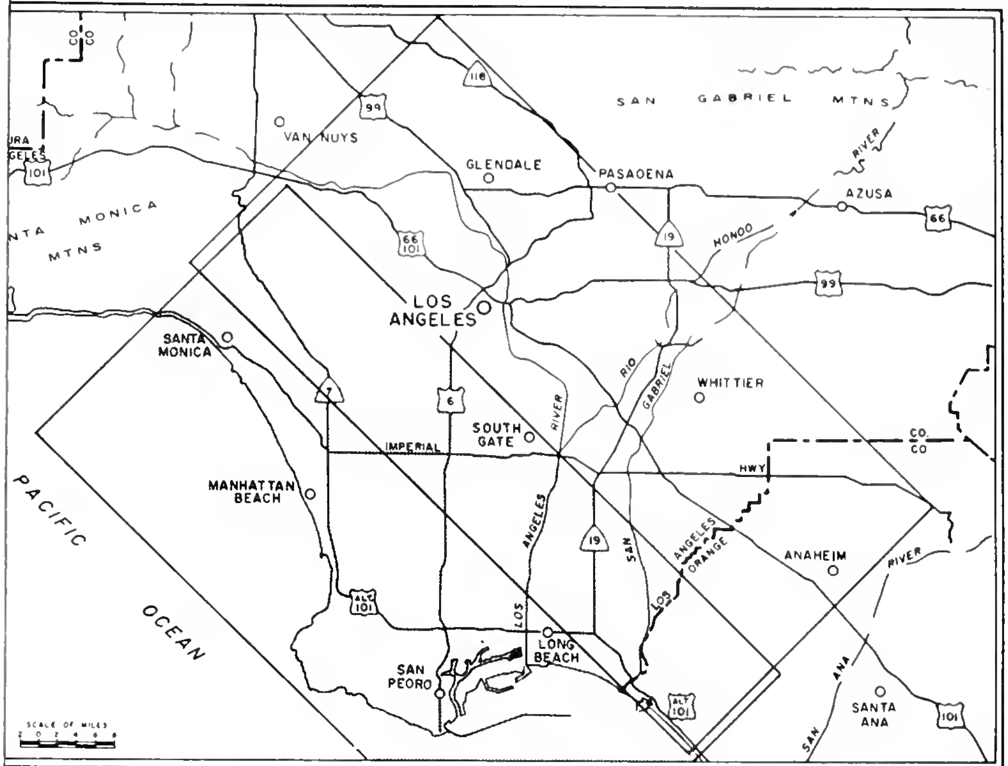
1961

PLATE 13A



GROUND WATER GEOLOGY OF THE COASTAL PLAIN OF LOS ANGELES COUNTY

LINES OF EQUAL THICKNESS OF THE GAGE AND GARDENA AQUIFERS



LOCATION MAP

LEGEND

SURFACE FEATURES

Qal	RECENT ALLUVIUM
Qpu	UPPER PLEISTOCENE DEPOSITS
	LOWER PLEISTOCENE DEPOSITS
	NONWATER-BEARING ROCKS

SUBSURFACE FEATURES

BOUNDARY OF AQUIFERS (DASHED WHERE LOCATION IS APPROXIMATE)

60 — LINES OF EQUAL THICKNESS OF THE GAGE AND GARDENA AQUIFERS (DASHED WHERE CONTROL IS POOR)

FAULT (DASHED WHERE APPROXIMATELY LOCATED)

GAGE AQUIFER

GARDENA AQUIFER

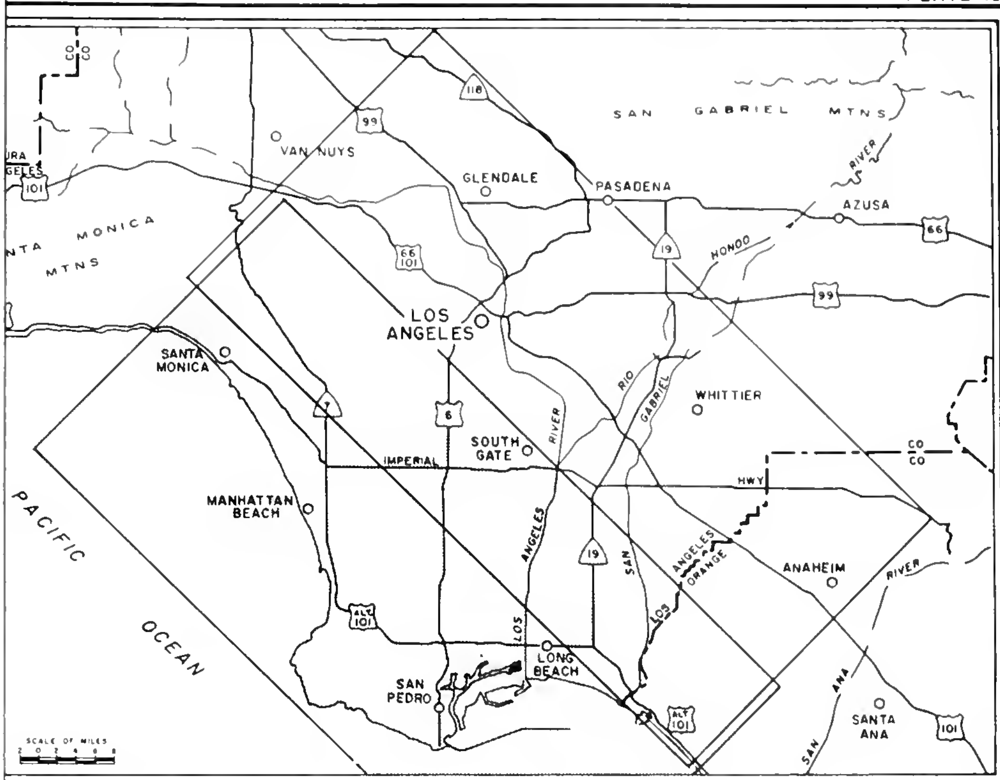
STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN CALIFORNIA DISTRICT

GROUND WATER GEOLOGY OF THE COASTAL PLAIN OF LOS ANGELES COUNTY

LINES OF EQUAL THICKNESS OF THE GAGE AND GARDENA AQUIFERS

SCALE OF MILES
1 0 1 2 3

1961



LOCATION MAP

LEGEND

SURFACE FEATURES

Qal	RECENT ALLUVIUM
Qpu	UPPER PLEISTOCENE DEPOSITS
	LOWER PLEISTOCENE DEPOSITS
	NONWATER-BEARING ROCKS

SUBSURFACE FEATURES

BOUNDARY OF AQUIFERS (DASHED WHERE LOCATION IS APPROXIMATE)

60 LINES OF EQUAL THICKNESS OF THE GAGE AND GARDENA AQUIFERS (DASHED WHERE CONTROL IS POOR)

FAULT (DASHED WHERE APPROXIMATELY LOCATED)

GAGE AQUIFER

GARDENA AQUIFER

STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN CALIFORNIA DISTRICT

GROUND WATER GEOLOGY OF THE COASTAL PLAIN OF LOS ANGELES COUNTY

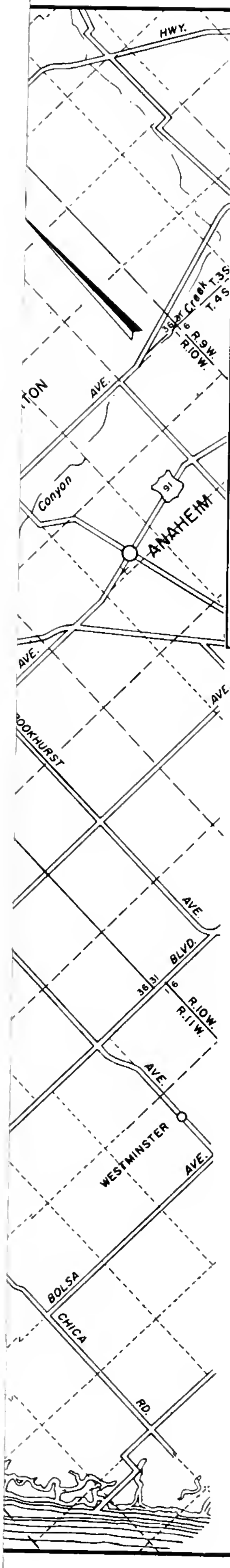
LINES OF EQUAL THICKNESS OF THE GAGE AND GARDENA AQUIFERS

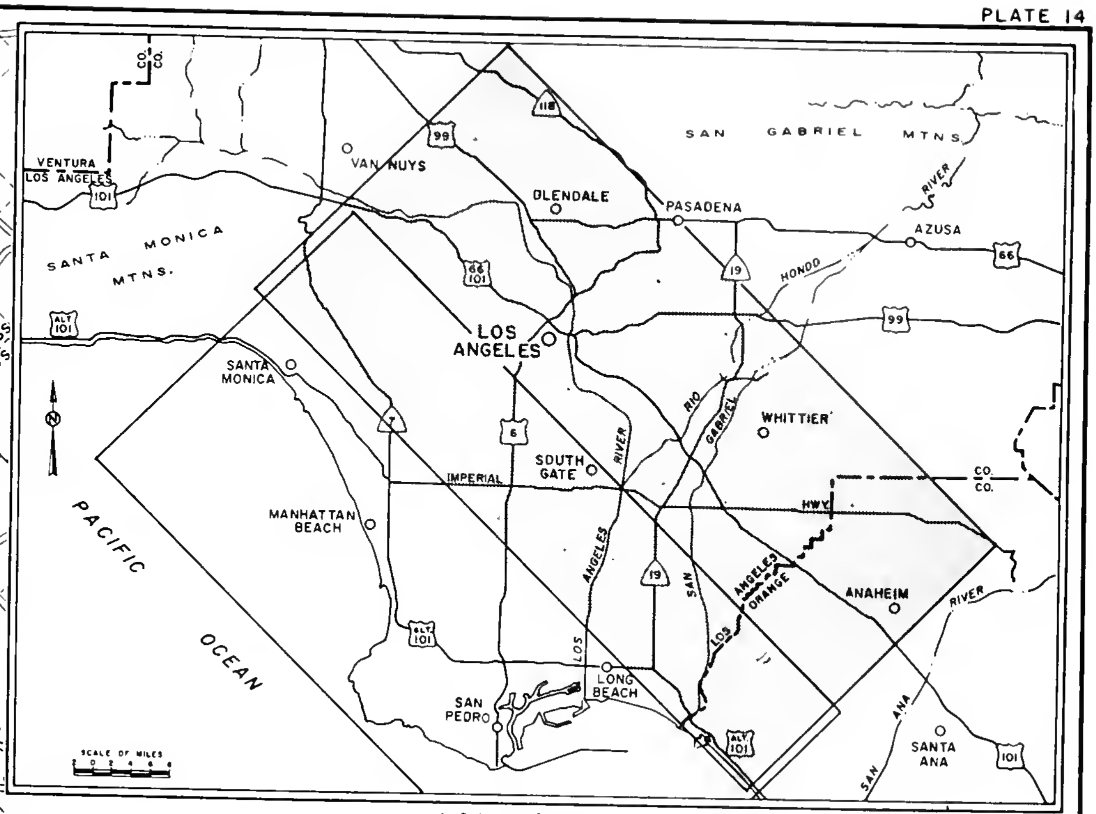
SCALE OF MILES

1 0 1 2 3

1961


BEVERLY HILLS
SOUTH GATE
LYNWOOD
COMPTON
BELLFLOWER
SAN GABRIEL
RIVER
LOS ANGELES
ORANGE
GARDENA
TORRANCE
HAWTHORNE
LONG BEACH
SANTA MONICA
MANHATTAN BEACH
REDONDO BEACH
HERMOSA BEACH
SAN PEDRO
SAN PEDRO BAY
SANTA MONICA BAY
PACIFIC OCEAN
LOCATION MAP
PASADENA
LOS ANGELES
SANTA MONICA
WHITTIER
SOUTH GATE
MANHATTAN BEACH
ANAHEIM
SAN PEDRO
LONG BEACH
PACIFIC OCEAN
LEGEND
Qal
Qpu
STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN CALIFORNIA DISTRICT
GROUND WATER GEOLOGY OF THE
COASTAL PLAIN OF
LOS ANGELES COUNTY
LINES OF EQUAL THICKNESS
OF THE GAGE AND GARDENA AQUIFERS





LOCATION MAP

LEGEND

SURFACE FEATURES

Qal	RECENT ALLUVIUM
Qpu	UPPER PLEISTOCENE DEPOSITS
	LOWER PLEISTOCENE DEPOSITS
	NONWATER-BEARING ROCKS

SUBSURFACE FEATURES

	BOUNDARY OF HOLLYDALE AQUIFER (DASHED WHERE LOCATION IS APPROXIMATE)
-50-	LINES OF EQUAL ELEVATION ON THE BASE OF THE HOLLYDALE AQUIFER (DASHED WHERE CONTROL IS POOR)
	FAULT (DASHED WHERE APPROXIMATELY LOCATED)
	KNOWN AREAS WHERE THE HOLLYDALE AQUIFER IS MERGED WITH THE OVERLYING AQUIFER

STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN CALIFORNIA DISTRICT

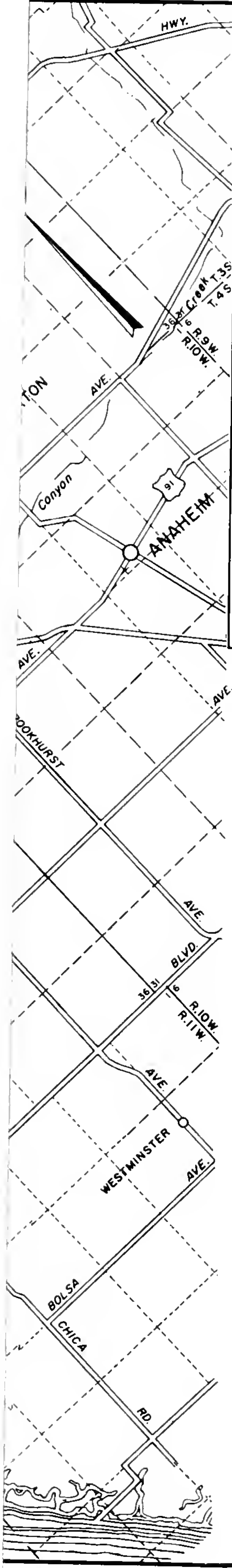
GROUND WATER GEOLOGY OF THE COASTAL PLAIN OF LOS ANGELES COUNTY

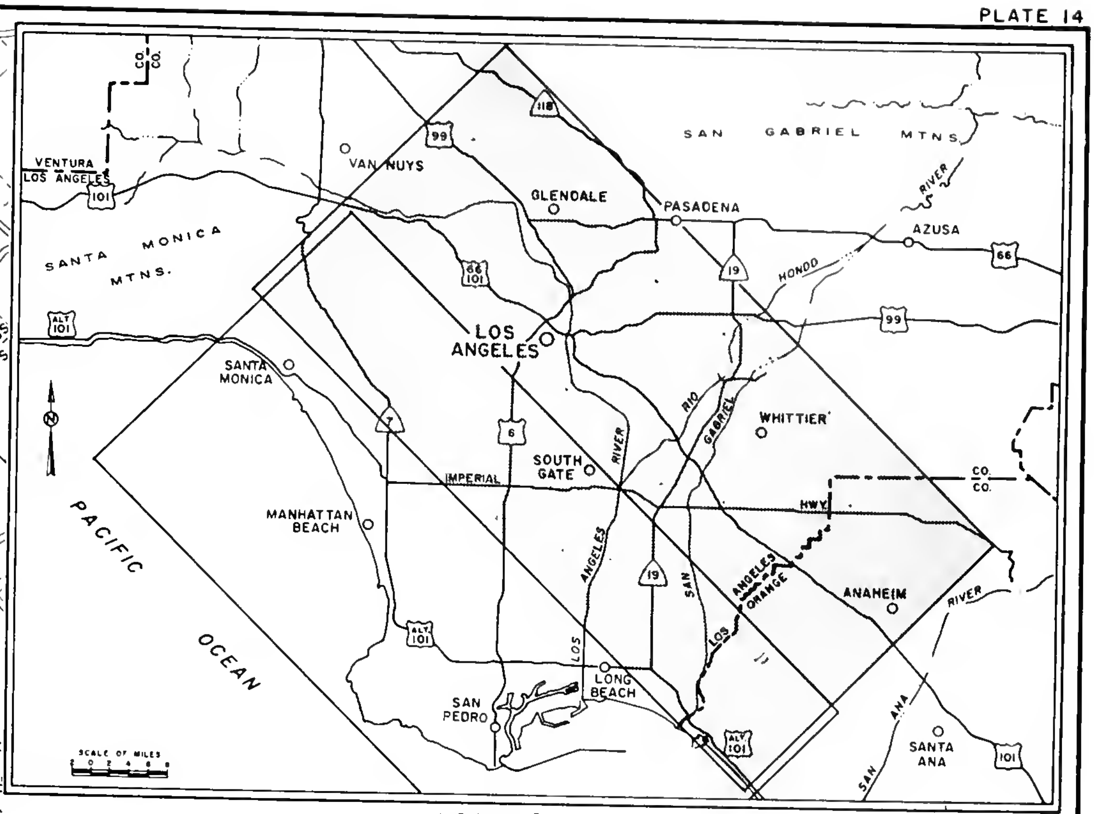
LINES OF EQUAL ELEVATION ON THE BASE OF THE HOLLYDALE AQUIFER

SCALE OF MILES

1 0 1 2 3

1961





LOCATION MAP

LEGEND

SURFACE FEATURES

- Qal — RECENT ALLUVIUM
- Qpu — UPPER PLEISTOCENE DEPOSITS
- LOWER PLEISTOCENE DEPOSITS
- NONWATER-BEARING ROCKS

SUBSURFACE FEATURES

- BOUNDARY OF HOLLYDALE AQUIFER (DASHED WHERE LOCATION IS APPROXIMATE)
- -50- LINES OF EQUAL ELEVATION ON THE BASE OF THE HOLLYDALE AQUIFER (DASHED WHERE CONTROL IS POOR)
- FAULT (DASHED WHERE APPROXIMATELY LOCATED)
- KNOWN AREAS WHERE THE HOLLYDALE AQUIFER IS MERGED WITH THE OVERLYING AQUIFER

STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN CALIFORNIA DISTRICT

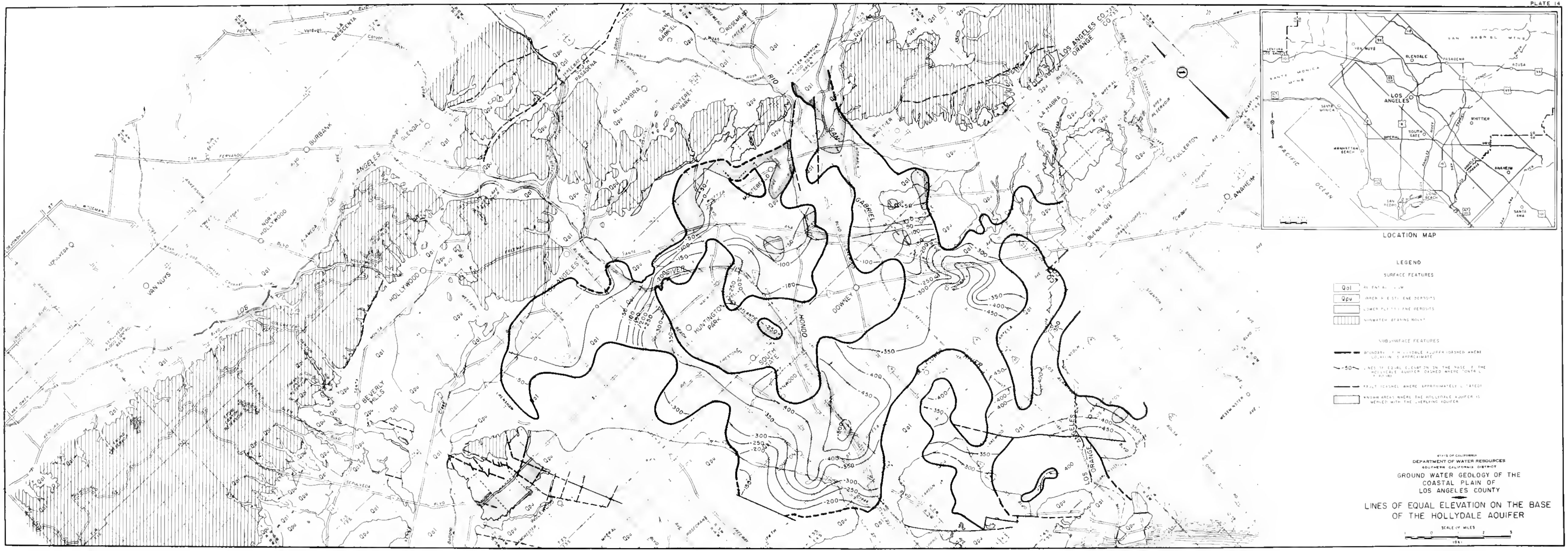
GROUND WATER GEOLOGY OF THE COASTAL PLAIN OF LOS ANGELES COUNTY

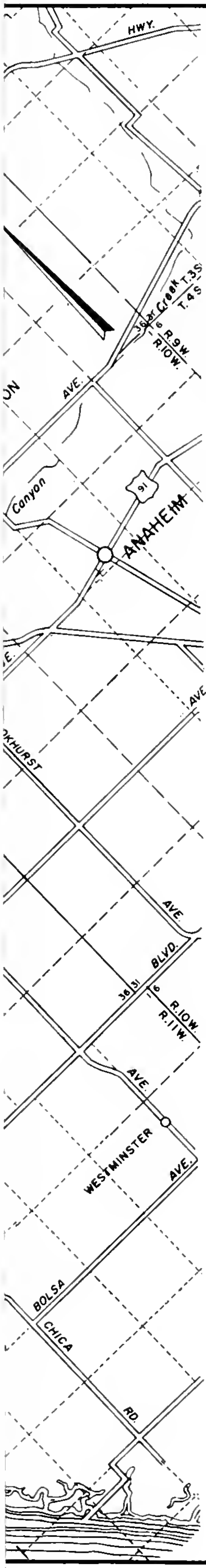
LINES OF EQUAL ELEVATION ON THE BASE OF THE HOLLYDALE AQUIFER

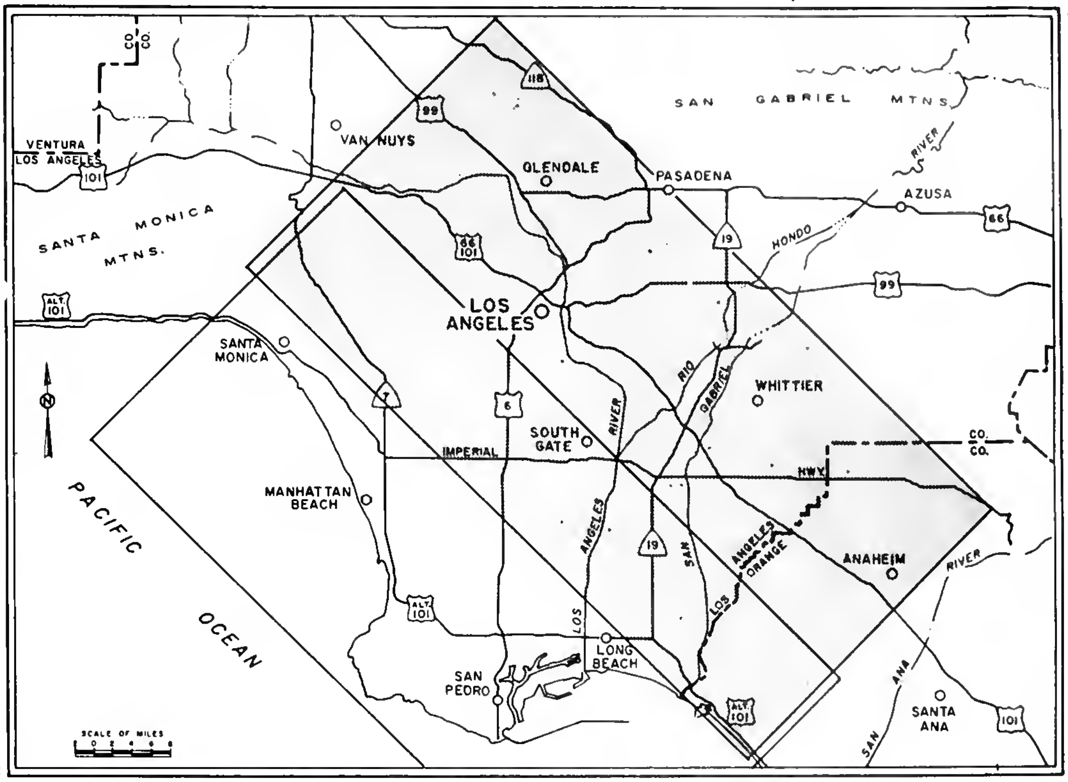
SCALE OF MILES

1 0 1 2 3

1961


LOCATION MAP
LEGEND
SURFACE FEATURES
Qal
Qpu
SUBSURFACE FEATURES
STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN CALIFORNIA DISTRICT
GROUND WATER GEOLOGY OF THE
COASTAL PLAIN OF
LOS ANGELES COUNTY
LINES OF EQUAL ELEVATION ON THE BASE
OF THE HOLLYDALE AQUIFER
SCALE OF MILES
BURBANK
GLENDALE
NORTH HOLLYWOOD
VAN NUYS
HOLLYWOOD
BEVERLY HILLS
ALHAMBRA
MONTEREY PARK
HUNTINGTON PARK
SOUTH GATE
DOWNEY
WHITTIER
LA HABRA
FULLERTON
ANAHEIM
BUENA PARK
LOS ANGELES CO.
ORANGE CO.





LOCATION MAP

LEGEND

SURFACE FEATURES

Qal	RECENT ALLUVIUM
Qpu	UPPER PLEISTOCENE DEPOSITS
	LOWER PLEISTOCENE DEPOSITS
	NONWATER-BEARING ROCKS

SUBSURFACE FEATURES

BOUNDARY OF HOLLYDALE AQUIFER (DASHED WHERE LOCATION IS APPROXIMATE)

~80~ LINES OF EQUAL THICKNESS ON THE BASE OF THE HOLLYDALE AQUIFER (DASHED WHERE CONTROL IS POOR)

FAULT (DASHED WHERE APPROXIMATELY LOCATED)

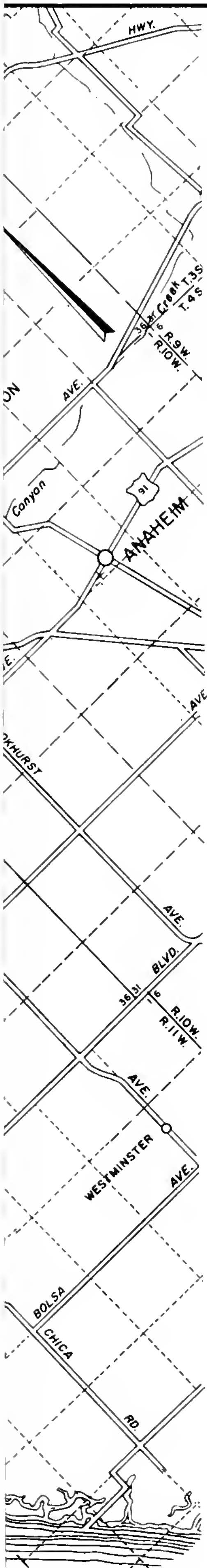
STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN CALIFORNIA DISTRICT

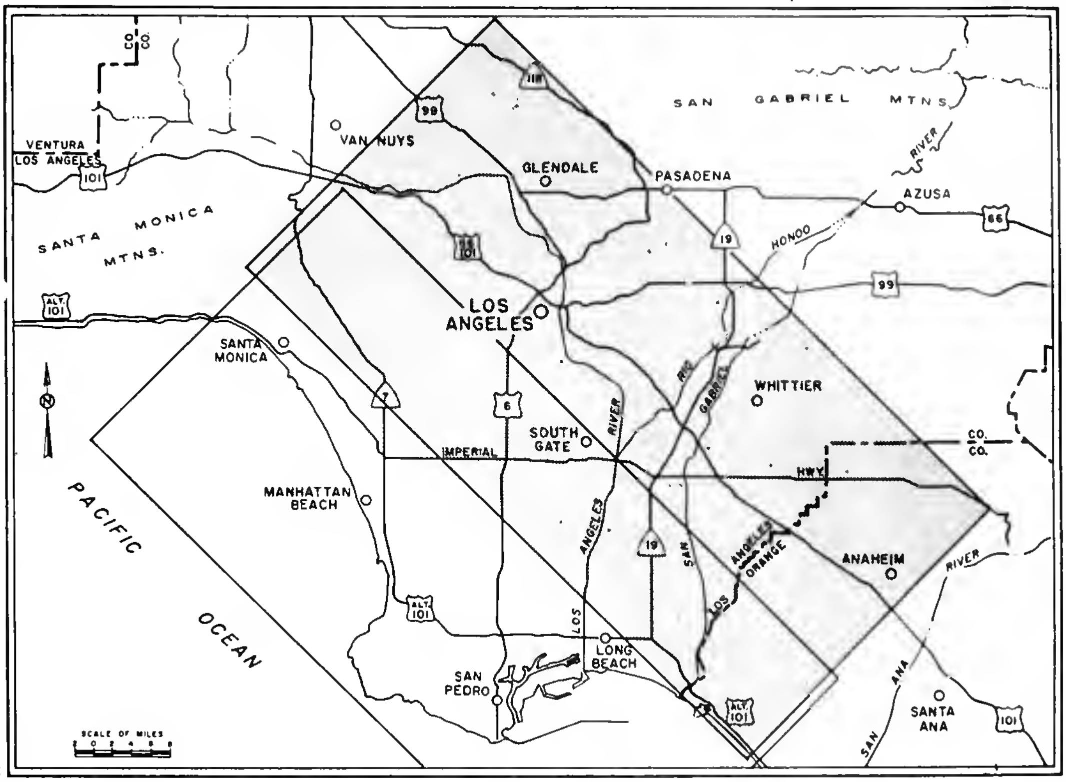
GROUND WATER GEOLOGY OF THE COASTAL PLAIN OF LOS ANGELES COUNTY

LINES OF EQUAL THICKNESS OF THE HOLLYDALE AQUIFER

SCALE OF MILES
1 0 1 2 3

1961





LOCATION MAP

LEGEND

SURFACE FEATURES

- Qal — RECENT ALLUVIUM
- Qpu — UPPER PLEISTOCENE DEPOSITS
- LOWER PLEISTOCENE DEPOSITS
- NONWATER-BEARING ROCKS

SUBSURFACE FEATURES

- BOUNDARY OF HOLLYDALE AQUIFER (DASHED WHERE LOCATION IS APPROXIMATE)
- —80— LINES OF EQUAL THICKNESS ON THE BASE OF THE HOLLYDALE AQUIFER (DASHED WHERE CONTROL IS POOR)
- FAULT (DASHED WHERE APPROXIMATELY LOCATED)

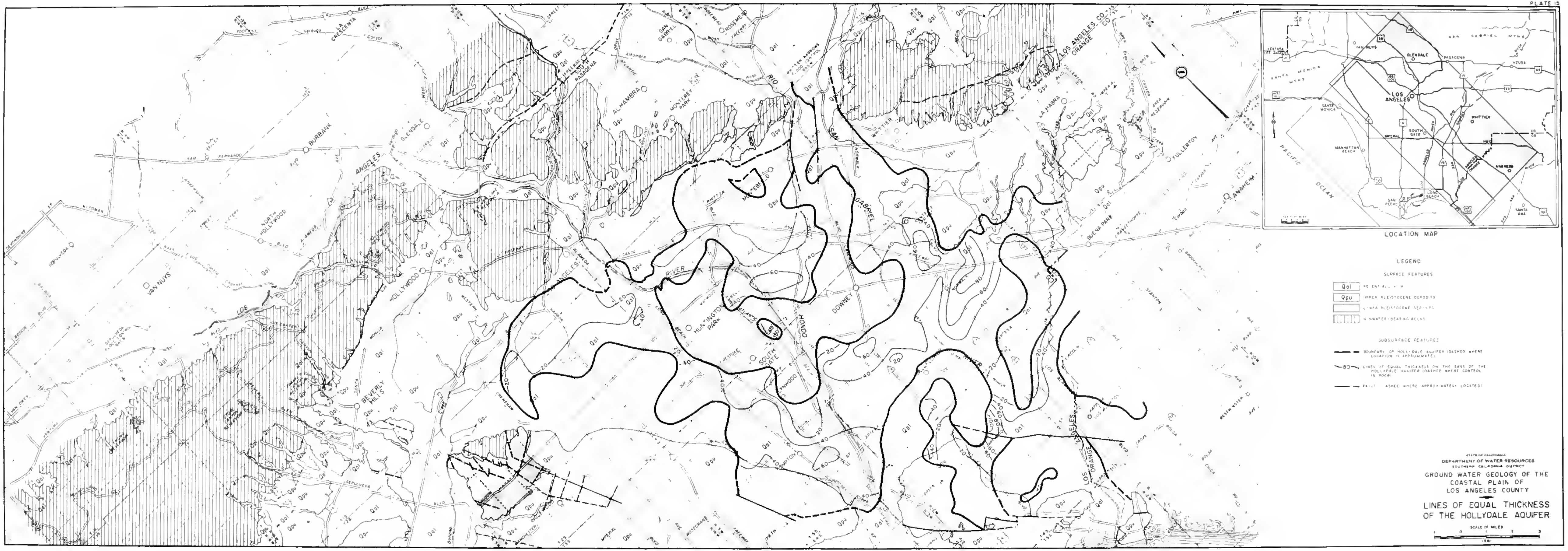
STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN CALIFORNIA DISTRICT

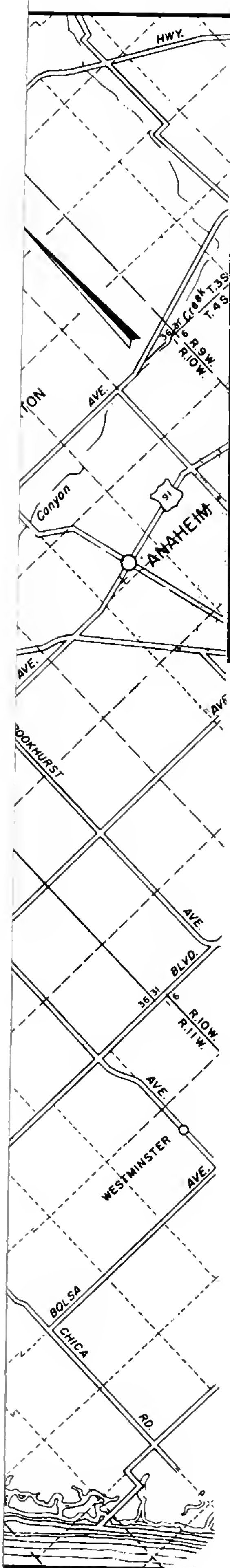
GROUND WATER GEOLOGY OF THE COASTAL PLAIN OF LOS ANGELES COUNTY

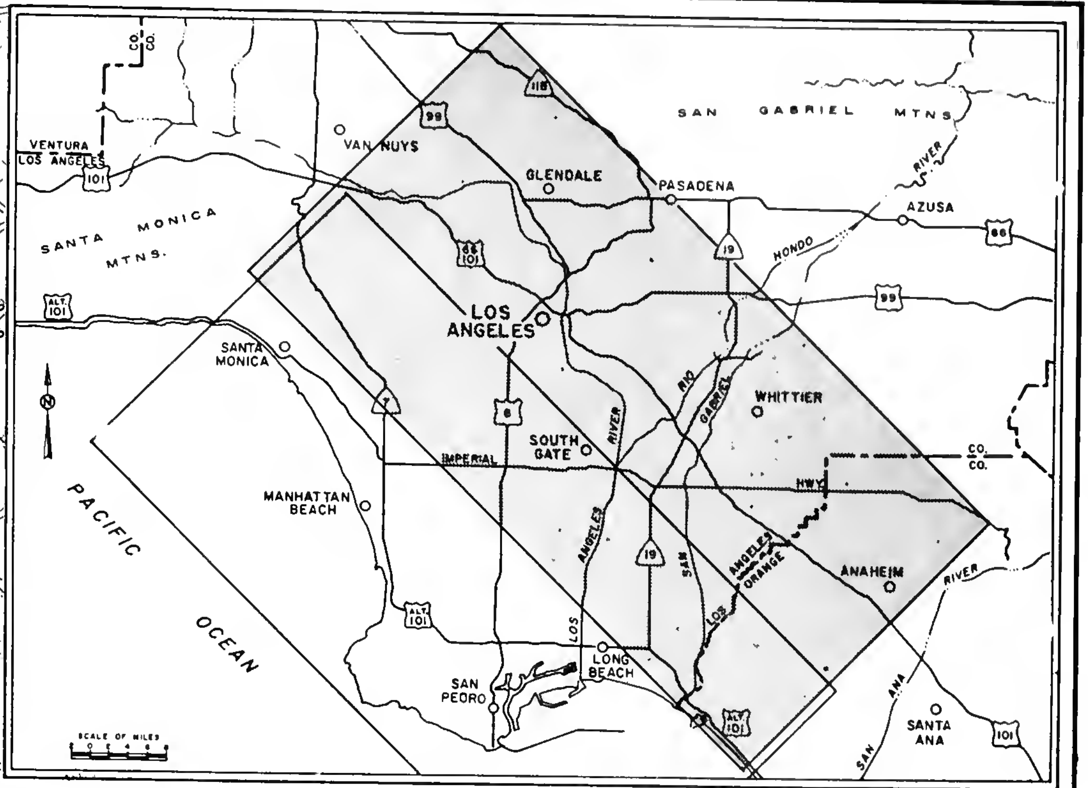
LINES OF EQUAL THICKNESS OF THE HOLLYDALE AQUIFER

SCALE OF MILES
1 0 1 2 3

1961


LOCATION MAP
LEGEND
SURFACE FEATURES
Qal
Qpu
UPPER PLEISTOCENE DEPOSITS
SUBSURFACE FEATURES
STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN CALIFORNIA DISTRICT
GROUND WATER GEOLOGY OF THE
COASTAL PLAIN OF
LOS ANGELES COUNTY
LINES OF EQUAL THICKNESS
OF THE HOLLYDALE AQUIFER
SCALE OF MILES
1961





LOCATION MAP

LEGEND

SURFACE FEATURES

Qal — RECENT ALLUVIUM

Qpu — UPPER PLEISTOCENE DEPOSITS

LOWER PLEISTOCENE DEPOSITS

NONWATER-BEARING ROCKS

SUBSURFACE FEATURES

BOUNDARY OF JEFFERSON AQUIFER (DASHED WHERE LOCATION IS APPROXIMATE)

--50— LINES OF EQUAL ELEVATION ON THE BASE OF THE JEFFERSON AQUIFER (DASHED WHERE CONTROL IS POOR)

FAULT (DASHED WHERE APPROXIMATELY LOCATED)

KNOWN AREAS WHERE THE JEFFERSON AQUIFER IS MERGED WITH THE OVERLYING AQUIFER

STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN CALIFORNIA DISTRICT

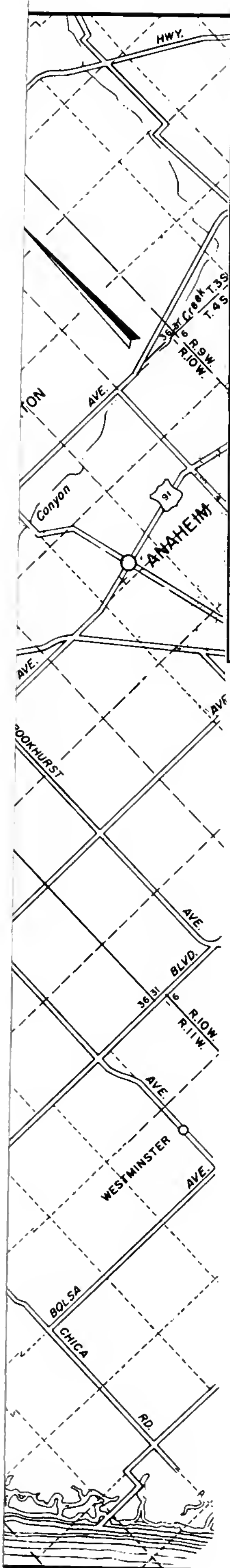
GROUND WATER GEOLOGY OF THE COASTAL PLAIN OF LOS ANGELES COUNTY

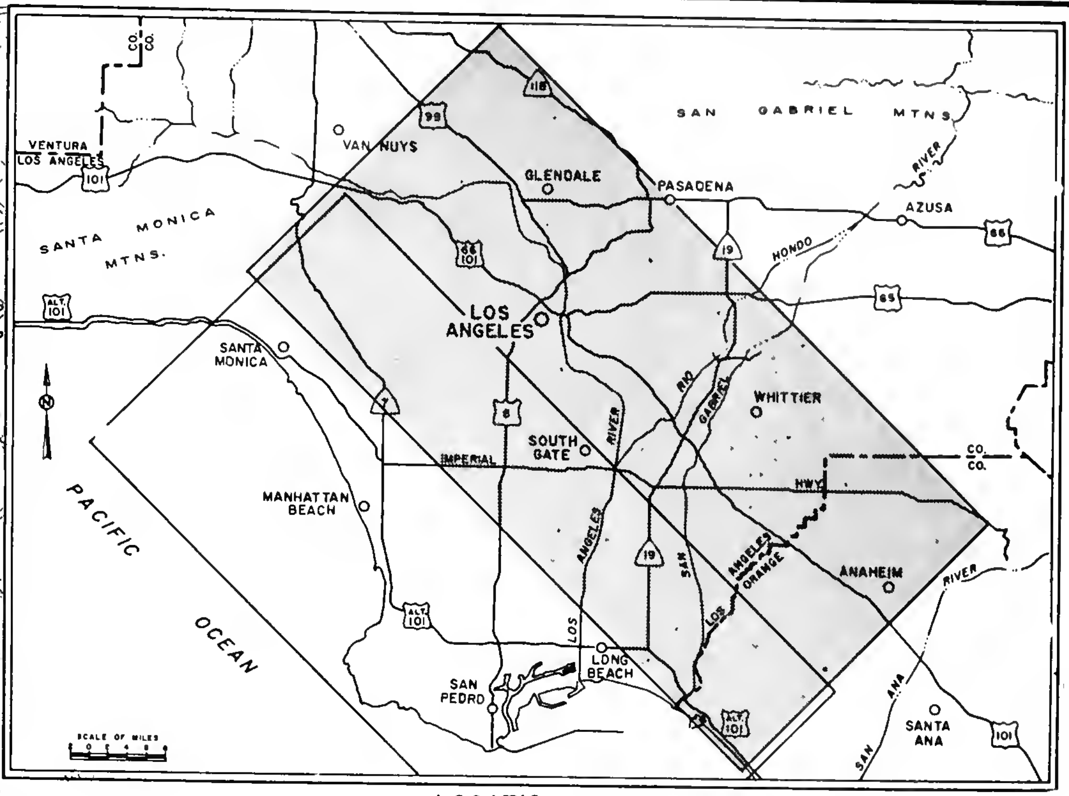
LINES OF EQUAL ELEVATION ON THE BASE OF THE JEFFERSON AQUIFER

SCALE OF MILES

1 0 1 2 3

1961





LOCATION MAP

LEGEND

SURFACE FEATURES

- Qal — RECENT ALLUVIUM
- Qpu — UPPER PLEISTOCENE DEPOSITS
- LOWER PLEISTOCENE DEPOSITS
- NONWATER-BEARING ROCKS

SUBSURFACE FEATURES

- BOUNDARY OF JEFFERSON AQUIFER (DASHED WHERE LOCATION IS APPROXIMATE)
- —50— LINES OF EQUAL ELEVATION ON THE BASE OF THE JEFFERSON AQUIFER (DASHED WHERE CONTROL IS POOR)
- FAULT (DASHED WHERE APPROXIMATELY LOCATED)
- KNOWN AREAS WHERE THE JEFFERSON AQUIFER IS MERGED WITH THE OVERLYING AQUIFER

STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN CALIFORNIA DISTRICT

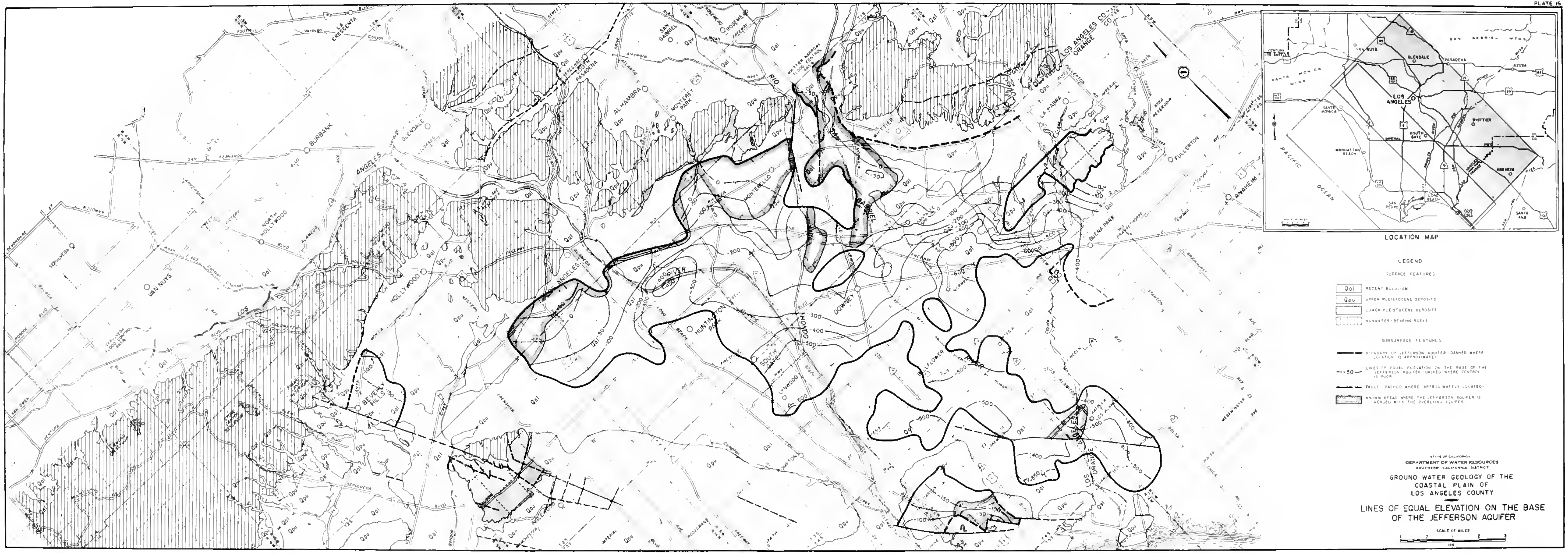
GROUND WATER GEOLOGY OF THE COASTAL PLAIN OF LOS ANGELES COUNTY

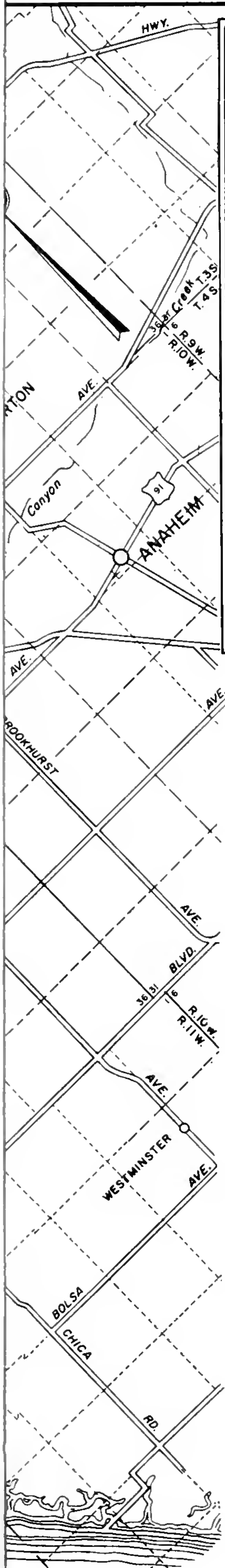
LINES OF EQUAL ELEVATION ON THE BASE OF THE JEFFERSON AQUIFER

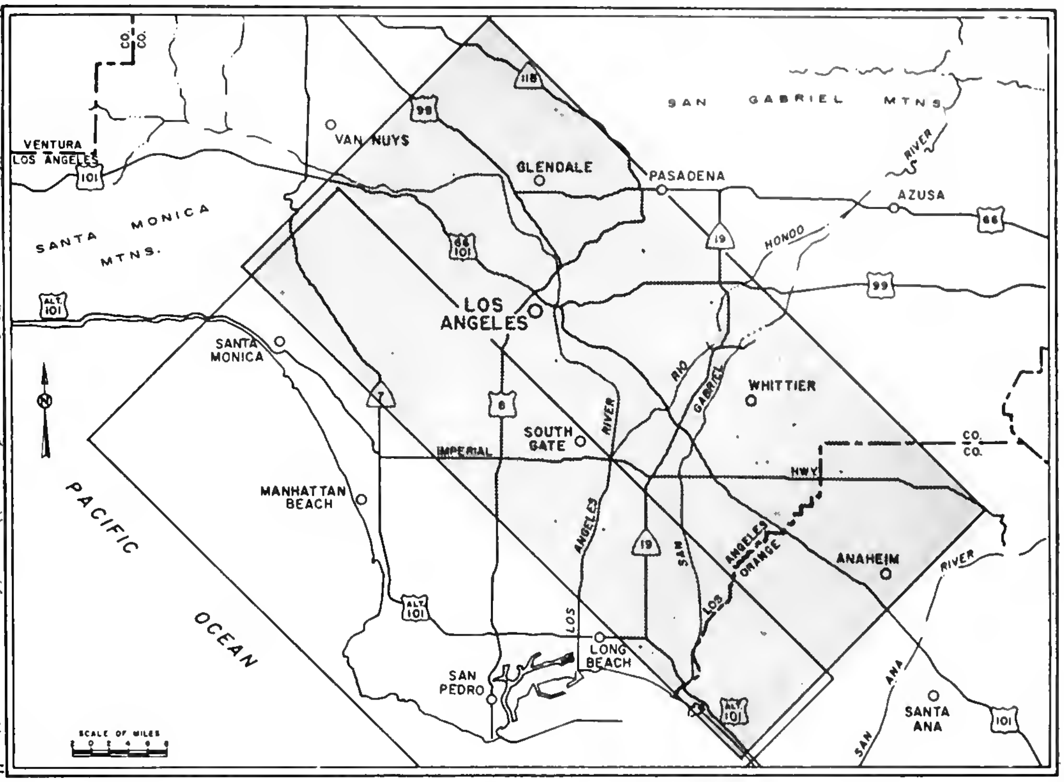
SCALE OF MILES

1 0 1 2 3

1961


LOCATION MAP
LEGEND
SURFACE FEATURES
Qal RECENT ALLUVIUM
Qpu UPPER PLEISTOCENE DEPOSITS
LOWER PLEISTOCENE DEPOSITS
NONWATER-BEARING ROCKS
SUBSURFACE FEATURES
BOUNDARY OF JEFFERSON AQUIFER (DASHED WHERE LOCATION IS APPROXIMATE)
-50 LINES OF EQUAL ELEVATION ON THE BASE OF THE JEFFERSON AQUIFER (DASHED WHERE CONTROL IS POOR)
FAULT (DASHED WHERE APPROXIMATELY LOCATED)
KNOWN AREAS WHERE THE JEFFERSON AQUIFER IS MERGED WITH THE OVERLYING AQUIFER
STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN CALIFORNIA DISTRICT
GROUND WATER GEOLOGY OF THE
COASTAL PLAIN OF
LOS ANGELES COUNTY
LINES OF EQUAL ELEVATION ON THE BASE
OF THE JEFFERSON AQUIFER
SCALE OF MILES
1 0 1 2 3
195





LOCATION MAP

LEGEND

SURFACE FEATURES

- Qal — RECENT ALLUVIUM
- Qpu — UPPER PLEISTOCENE DEPOSITS
- LOWER PLEISTOCENE DEPOSITS
- NONWATER-BEARING ROCKS

SUBSURFACE FEATURES

- BOUNDARY OF JEFFERSON AQUIFER (DASHED WHERE LOCATION IS APPROXIMATE)
- —40— LINES OF EQUAL THICKNESS OF THE JEFFERSON AQUIFER (DASHED WHERE CONTROL IS POOR)
- FAULT (DASHED WHERE APPROXIMATELY LOCATED)
- KNOWN AREAS WHERE THE JEFFERSON AQUIFER IS COMPOSED OF COARSE GRAINED SEDIMENTS

STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN CALIFORNIA DISTRICT

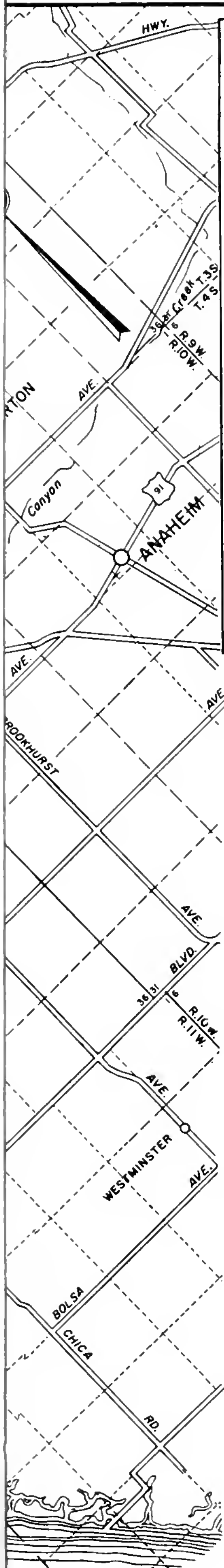
GROUND WATER GEOLOGY OF THE COASTAL PLAIN OF LOS ANGELES COUNTY

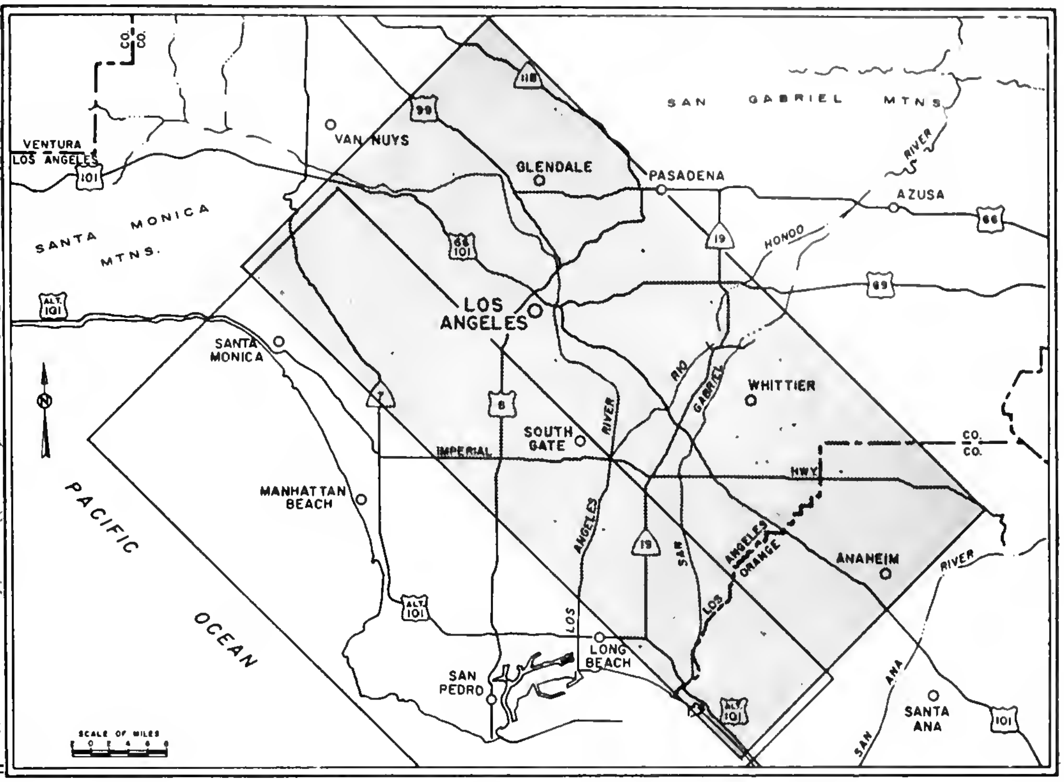
LINES OF EQUAL THICKNESS OF THE JEFFERSON AQUIFER

SCALE OF MILES

1 0 1 2 3

1961





LOCATION MAP

LEGEND

SURFACE FEATURES

Qal	RECENT ALLUVIUM
Qpu	UPPER PLEISTOCENE DEPOSITS
	LOWER PLEISTOCENE DEPOSITS
	NONWATER-BEARING ROCKS

SUBSURFACE FEATURES

	BOUNDARY OF JEFFERSON AQUIFER (DASHED WHERE LOCATION IS APPROXIMATE)
—40—	LINES OF EQUAL THICKNESS OF THE JEFFERSON AQUIFER (DASHED WHERE CONTROL IS POOR)
	FAULT (DASHED WHERE APPROXIMATELY LOCATED)
	KNOWN AREAS WHERE THE JEFFERSON AQUIFER IS COMPOSED OF COARSE GRAINED SEDIMENTS

STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN CALIFORNIA DISTRICT

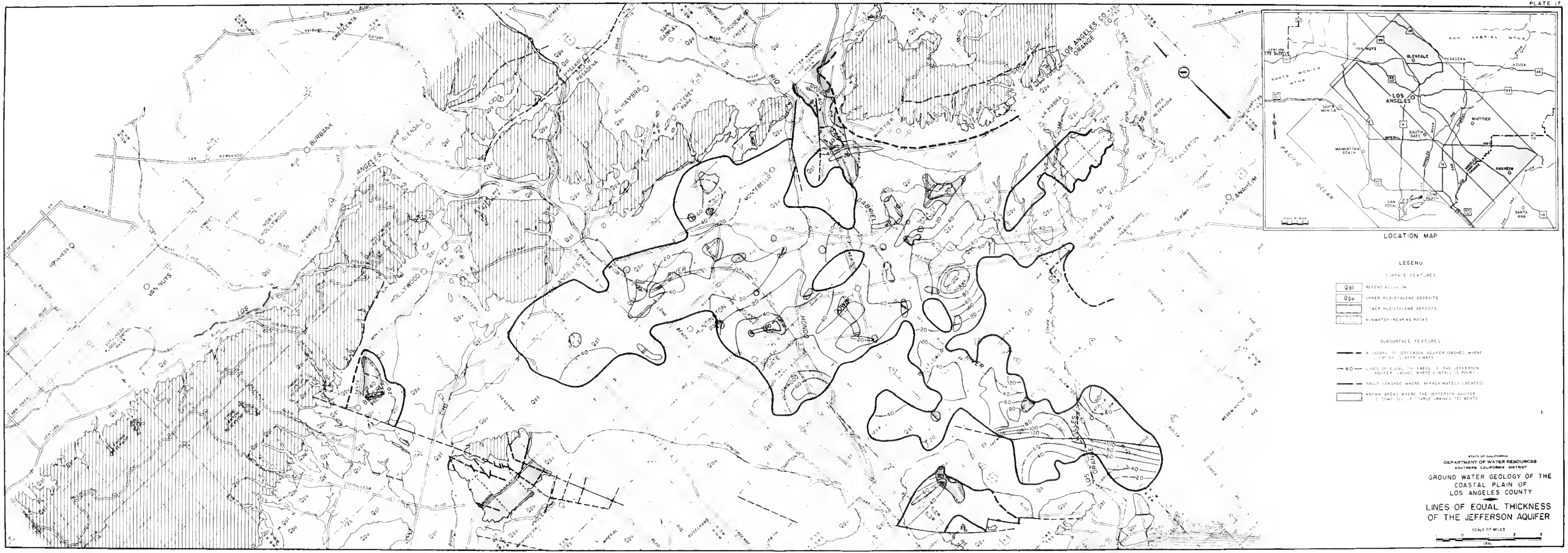
GROUND WATER GEOLOGY OF THE COASTAL PLAIN OF LOS ANGELES COUNTY

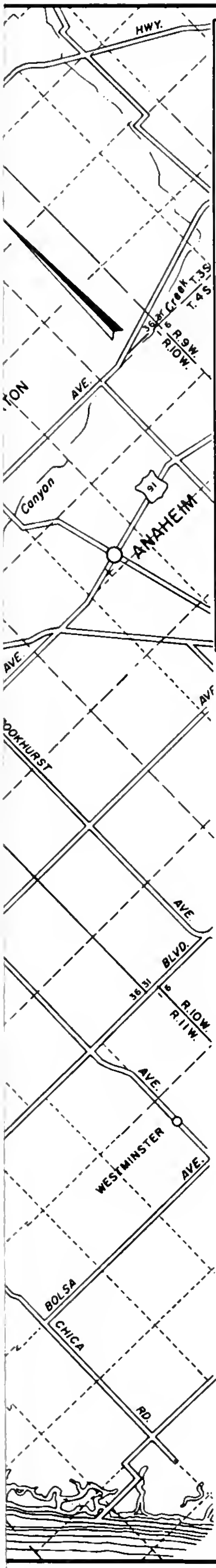
LINES OF EQUAL THICKNESS OF THE JEFFERSON AQUIFER

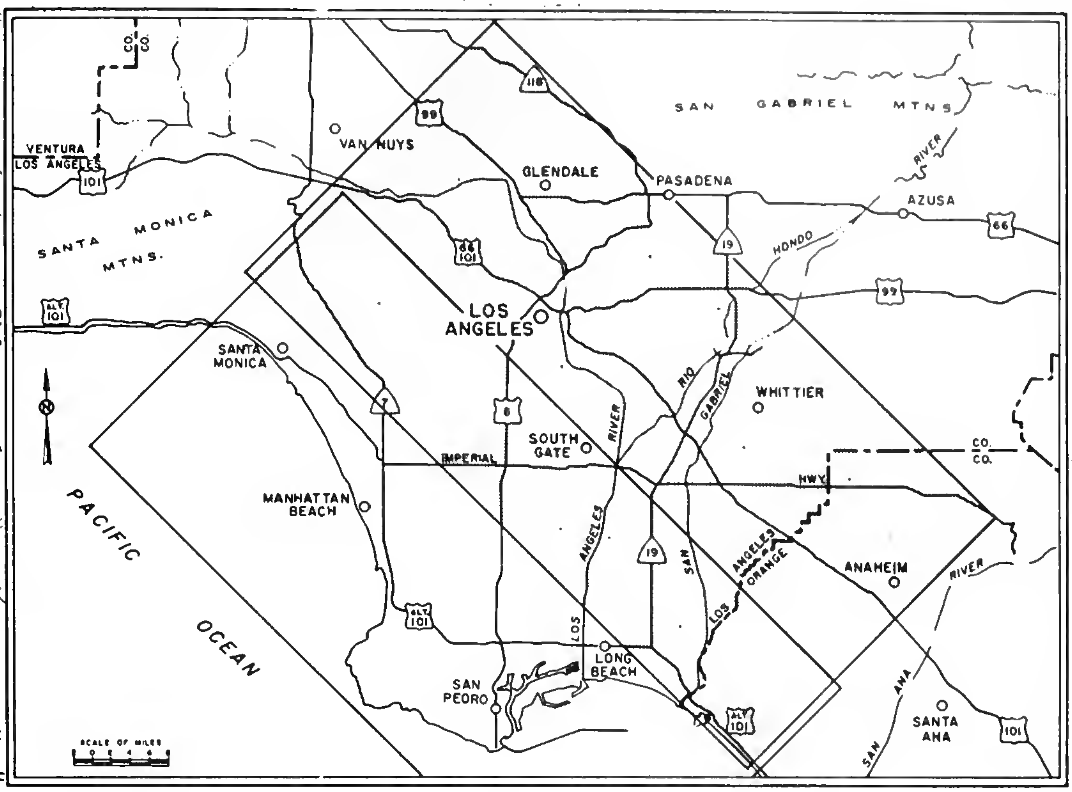
SCALE OF MILES

1 0 1 2 3

1961


LOCATION MAP
LEGEND
SURFACE FEATURES
Qal RECENT ALLUVIUM
Qpu UPPER PLEISTOCENE DEPOSITS
LOWER PLEISTOCENE DEPOSITS
NONWATER-BEARING ROCKS
SUBSURFACE FEATURES
BOUNDARY OF JEFFERSON AQUIFER (DASHED WHERE LOCATION IS APPROXIMATE)
40 LINES OF EQUAL THICKNESS OF THE JEFFERSON AQUIFER (DASHED WHERE CONTROL IS POOR)
FAULT (DASHED WHERE APPROXIMATELY LOCATED)
KNOWN AREAS WHERE THE JEFFERSON AQUIFER IS COMPOSED OF COARSE GRAINED SEDIMENTS
STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN CALIFORNIA DISTRICT
GROUND WATER GEOLOGY OF THE COASTAL PLAIN OF LOS ANGELES COUNTY
LINES OF EQUAL THICKNESS OF THE JEFFERSON AQUIFER
SCALE OF MILES
1961
VAN NUYS
BURBANK
GLENDALE
NORTH HOLLYWOOD
HOLLYWOOD
PASADENA
SAN GABRIEL
ROSEMEAD
ALHAMBRA
MONTEREY PARK
MONTEBELLO
WHITTIER
LA MIRADA
FULLERTON
ANAHEIM
BUENA PARK
SOUTH GATE
COMPTON
LOS ANGELES CO.
ORANGE CO.
LOS ANGELES
SANTA MONICA
MANHATTAN BEACH
SAN PEDRO
SANTA ANA
PACIFIC OCEAN
SAN GABRIEL MTNS
SANTA MONICA MTNS
AZUSA





LOCATION MAP

LEGEND

SURFACE FEATURES

Qal	RECENT ALLUVIUM
Qpu	UPPER PLEISTOCENE DEPOSITS
	LOWER PLEISTOCENE DEPOSITS
	NONWATER-BEARING ROCKS

SUBSURFACE FEATURES

BOUNDARY OF LYNWOOD AQUIFER (DASHED WHERE LOCATION IS APPROXIMATE)

--50-- LINES OF EQUAL ELEVATION ON THE BASE OF THE LYNWOOD AQUIFER (DASHED WHERE CONTROL IS POOR)

FAULT (DASHED WHERE APPROXIMATELY LOCATED)

KNOWN AREAS WHERE THE LYNWOOD AQUIFER IS MERGED WITH THE OVERLYING AQUIFER

NOTE. IN WEST COAST BASIN THE LYNWOOD AQUIFER WAS PREVIOUSLY CALLED "400 FOOT GRAVEL"

STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN CALIFORNIA DISTRICT

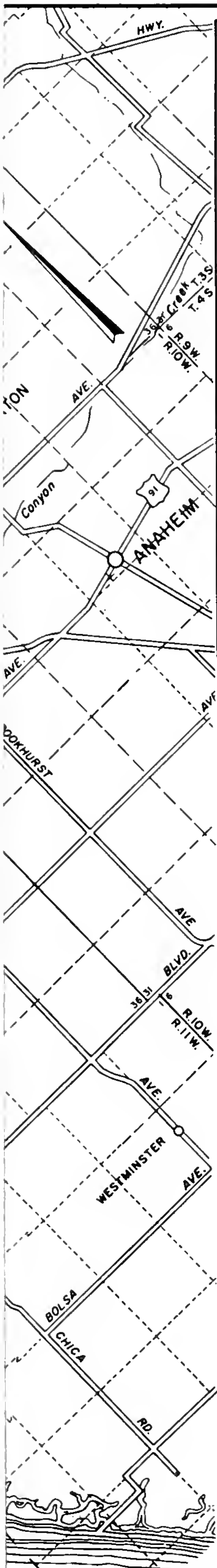
GROUND WATER GEOLOGY OF THE COASTAL PLAIN OF LOS ANGELES COUNTY

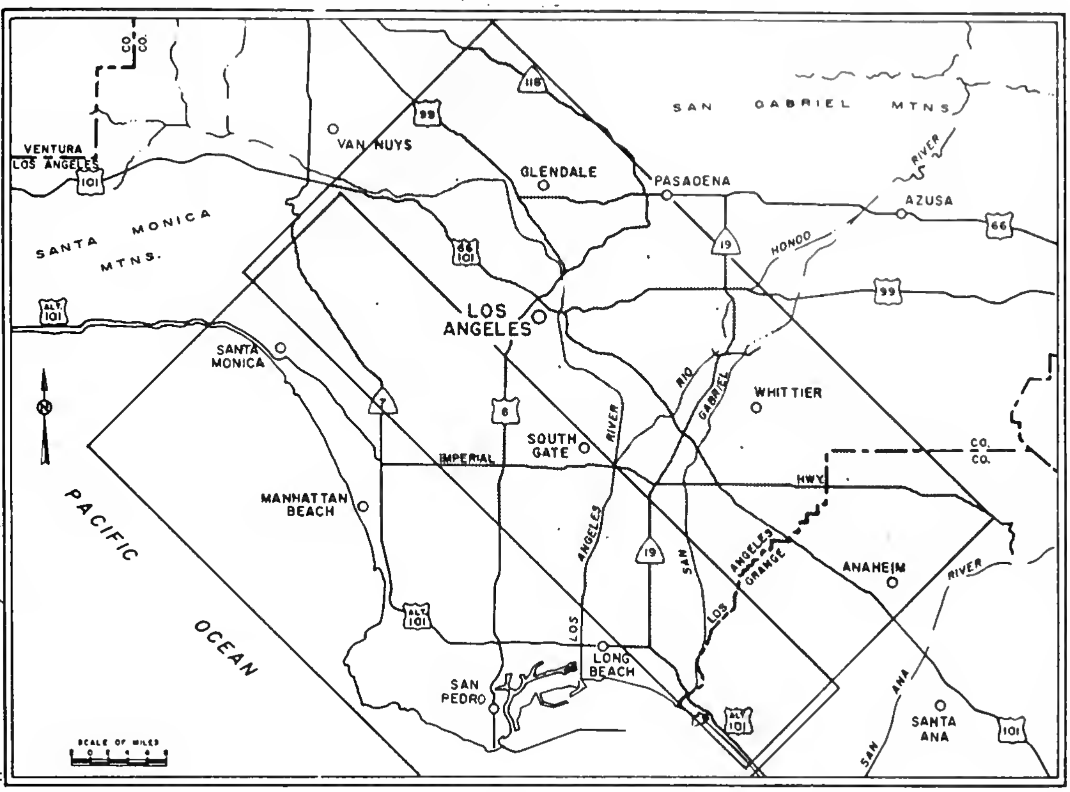
LINES OF EQUAL ELEVATION ON THE BASE OF THE LYNWOOD AQUIFER

SCALE OF MILES

1 0 1 2 3

1961





LOCATION MAP

LEGEND

SURFACE FEATURES

Qal — RECENT ALLUVIUM

Qpu — UPPER PLEISTOCENE DEPOSITS

LOWER PLEISTOCENE DEPOSITS

NONWATER-BEARING ROCKS

SUBSURFACE FEATURES

BOUNDARY OF LYNWOOD AQUIFER (DASHED WHERE LOCATION IS APPROXIMATE)

-50 — LINES OF EQUAL ELEVATION ON THE BASE OF THE LYNWOOD AQUIFER (DASHED WHERE CONTROL IS POOR)

FAULT (DASHED WHERE APPROXIMATELY LOCATED)

KNOWN AREAS WHERE THE LYNWOOD AQUIFER IS MERGED WITH THE OVERLYING AQUIFER

NOTE. IN WEST COAST BASIN THE LYNWOOD AQUIFER WAS PREVIOUSLY CALLED "400 FOOT GRAVEL"

STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN CALIFORNIA DISTRICT

GROUND WATER GEOLOGY OF THE COASTAL PLAIN OF LOS ANGELES COUNTY

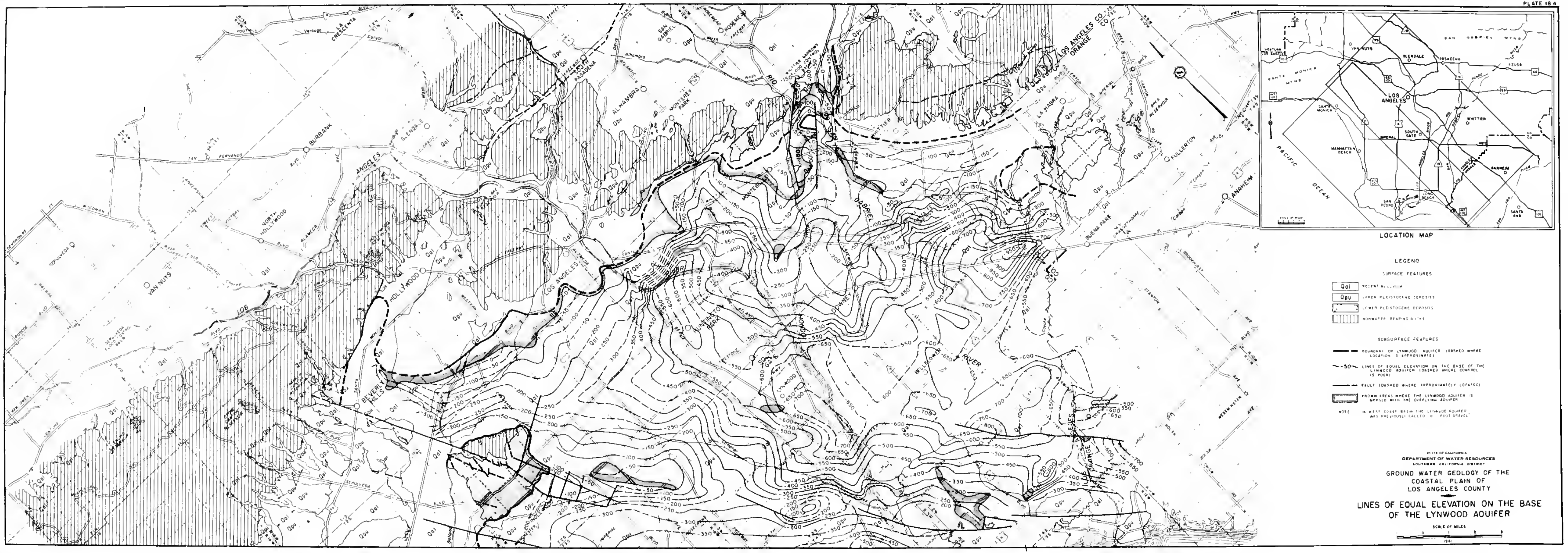
LINES OF EQUAL ELEVATION ON THE BASE OF THE LYNWOOD AQUIFER

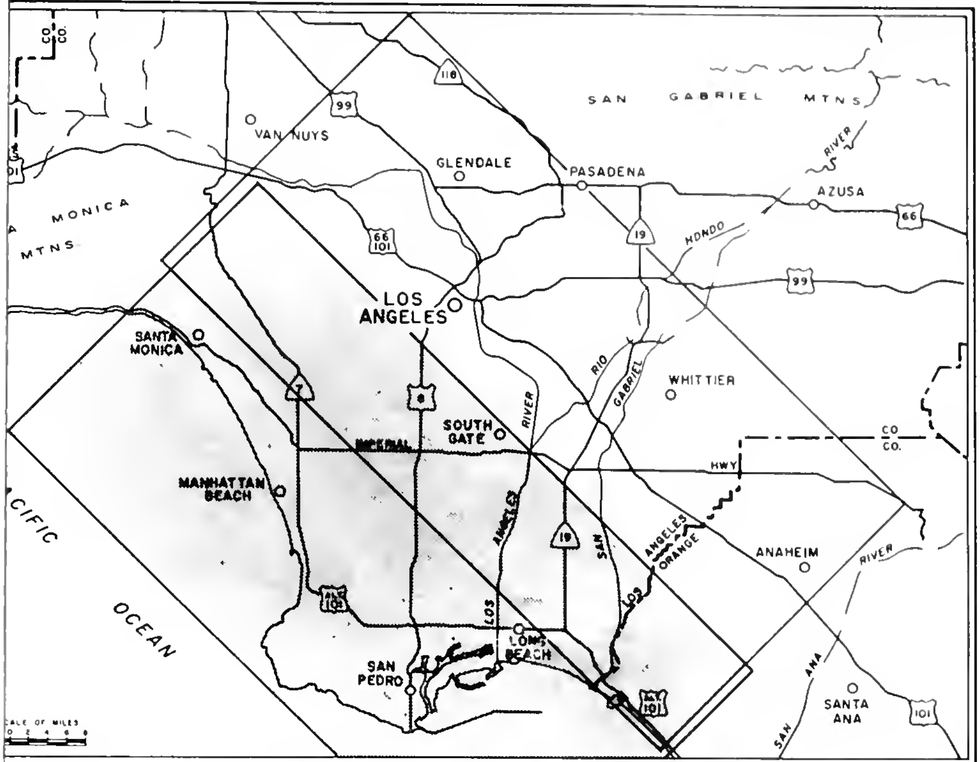
SCALE OF MILES

1 0 1 2 3

1961

PLATE 18 A


LOCATION MAP
LEGEND
SURFACE FEATURES
Qal RECENT ALLUVIUM
Qpu UPPER PLEISTOCENE DEPOSITS
LOWER PLEISTOCENE DEPOSITS
NONWATER BEARING ROCKS
SUBSURFACE FEATURES
BOUNDARY OF LYNWOOD AQUIFER (DASHED WHERE LOCATION IS APPROXIMATE)
-50 LINES OF EQUAL ELEVATION ON THE BASE OF THE LYNWOOD AQUIFER (DASHED WHERE CONTROL IS POOR)
FAULT (DASHED WHERE APPROXIMATELY LOCATED)
KNOWN AREAS WHERE THE LYNWOOD AQUIFER IS MERGED WITH THE OVERLYING AQUIFER
NOTE IN WEST COAST BASIN THE LYNWOOD AQUIFER WAS PREVIOUSLY CALLED "400 FOOT GRAVEL"
STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN CALIFORNIA DISTRICT
GROUND WATER GEOLOGY OF THE COASTAL PLAIN OF LOS ANGELES COUNTY
LINES OF EQUAL ELEVATION ON THE BASE OF THE LYNWOOD AQUIFER
SCALE OF MILES
1961



LOCATION MAP

LEGEND

SURFACE FEATURES

Qal	RECENT ALLUVIUM
Qpu	UPPER PLEISTOCENE DEPOSITS
	LOWER PLEISTOCENE DEPOSITS
	NONWATER-BEARING ROCKS

SUBSURFACE FEATURES

BOUNDARY OF LYNWOOD AQUIFER (DASHED WHERE LOCATION IS APPROXIMATE)

—-50— LINES OF EQUAL ELEVATION ON THE BASE OF THE LYNWOOD AQUIFER (DASHED WHERE CONTROL IS POOR)

FAULT (DASHED WHERE APPROXIMATELY LOCATED)

KNOWN AREAS WHERE THE LYNWOOD AQUIFER IS MERGED WITH THE OVERLYING AQUIFER

NOTE IN WEST COAST BASIN THE LYNWOOD AQUIFER WAS PREVIOUSLY CALLED "400 FOOT GRAVEL"

STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN CALIFORNIA DISTRICT

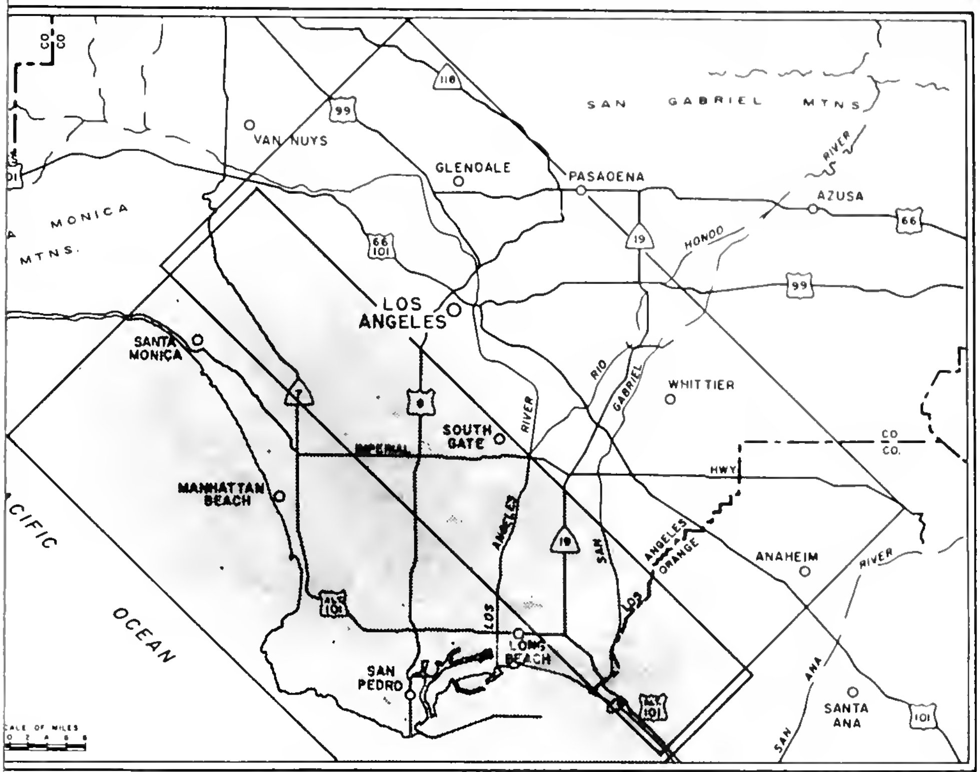
GROUND WATER GEOLOGY OF THE COASTAL PLAIN OF LOS ANGELES COUNTY

LINES OF EQUAL ELEVATION ON THE BASE OF THE LYNWOOD AQUIFER

SCALE OF MILES

1 0 1 2 3

1961



LOCATION MAP

LEGEND

SURFACE FEATURES

Qal	RECENT ALLUVIUM
Qpu	UPPER PLEISTOCENE DEPOSITS
	LOWER PLEISTOCENE DEPOSITS
	NONWATER-BEARING ROCKS

SUBSURFACE FEATURES

BOUNDARY OF LYNWOOD AQUIFER (DASHED WHERE LOCATION IS APPROXIMATE)

—-50— LINES OF EQUAL ELEVATION ON THE BASE OF THE LYNWOOD AQUIFER (DASHED WHERE CONTROL IS POOR)

FAULT (DASHED WHERE APPROXIMATELY LOCATED)

KNOWN AREAS WHERE THE LYNWOOD AQUIFER IS MERGED WITH THE OVERLYING AQUIFER

NOTE IN WEST COAST BASIN THE LYNWOOD AQUIFER WAS PREVIOUSLY CALLED "400 FOOT GRAVEL"

STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN CALIFORNIA DISTRICT

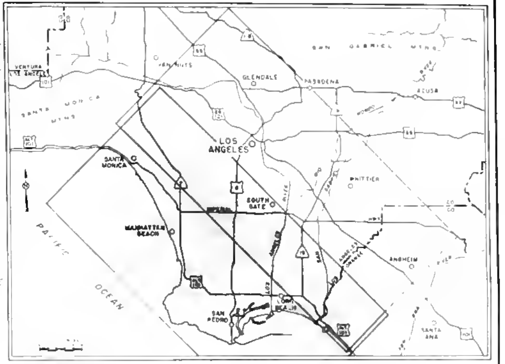
GROUND WATER GEOLOGY OF THE
COASTAL PLAIN OF
LOS ANGELES COUNTY

LINES OF EQUAL ELEVATION ON THE BASE OF THE LYNWOOD AQUIFER

SCALE OF MILES

1 0 1 2 3

1961



LOCATION MAP

LEGEND

SURFACE FEATURES

Qal

Qpu

SUBSURFACE FEATURES

-50

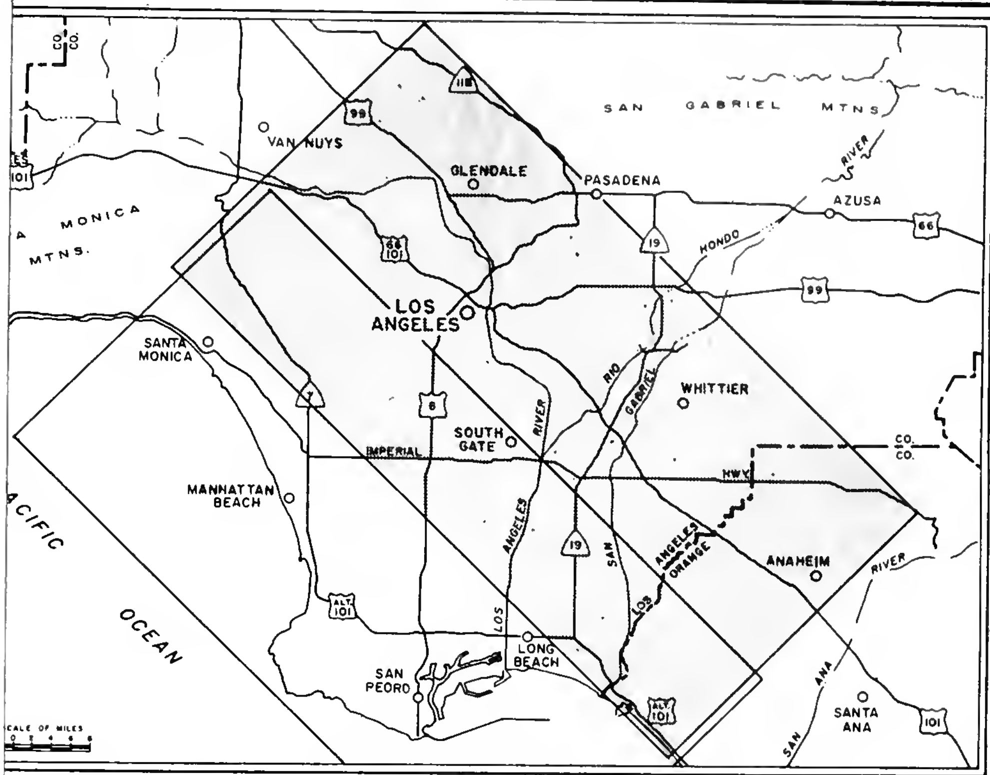
STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN CALIFORNIA DISTRICT

GROUND WATER GEOLOGY OF THE
COASTAL PLAIN OF
LOS ANGELES COUNTY

LINES OF EQUAL ELEVATION ON THE BASE
OF THE LYNWOOD AQUIFER

SCALE OF MILES

1961



LOCATION MAP

LEGEND

SURFACE FEATURES

Qal	RECENT ALLUVIUM
Qpu	UPPER PLEISTOCENE DEPOSITS
	LOWER PLEISTOCENE DEPOSITS
	NONWATER-BEARING ROCKS

SUBSURFACE FEATURES

	BOUNDARY OF LYNWOOD AQUIFER (DASHED WHERE LOCATION IS APPROXIMATE)
100	LINES OF EQUAL THICKNESS OF THE LYNWOOD AQUIFER (DASHED WHERE CONTROL IS POOR)
	FAULT (DASHED WHERE APPROXIMATELY LOCATED)
	KNOWN AREAS WHERE THE LYNWOOD AQUIFER IS COMPOSED OF FINE GRAINED SEDIMENTS

STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN CALIFORNIA DISTRICT

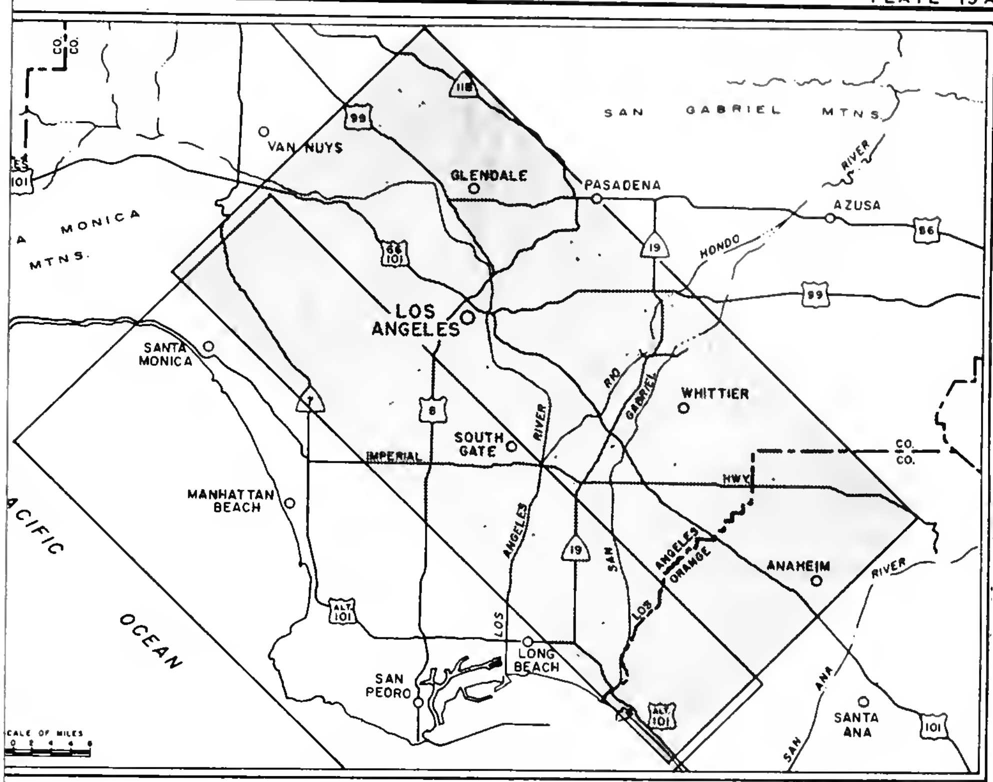
GROUND WATER GEOLOGY OF THE COASTAL PLAIN OF LOS ANGELES COUNTY

LINES OF EQUAL THICKNESS OF THE LYNWOOD AQUIFER

SCALE OF MILES

1 0 1 2 3

1961



LOCATION MAP

LEGEND

SURFACE FEATURES

Qal RECENT ALLUVIUM

Qpu UPPER PLEISTOCENE DEPOSITS

LOWER PLEISTOCENE DEPOSITS

NONWATER-BEARING ROCKS

SUBSURFACE FEATURES

BOUNDARY OF LYNWOOD AQUIFER (DASHED WHERE LOCATION IS APPROXIMATE)

100 LINES OF EQUAL THICKNESS OF THE LYNWOOD AQUIFER (DASHED WHERE CONTROL IS POOR)

FAULT (DASHED WHERE APPROXIMATELY LOCATED)

KNOWN AREAS WHERE THE LYNWOOD AQUIFER IS COMPOSED OF FINE GRAINED SEDIMENTS

STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN CALIFORNIA DISTRICT

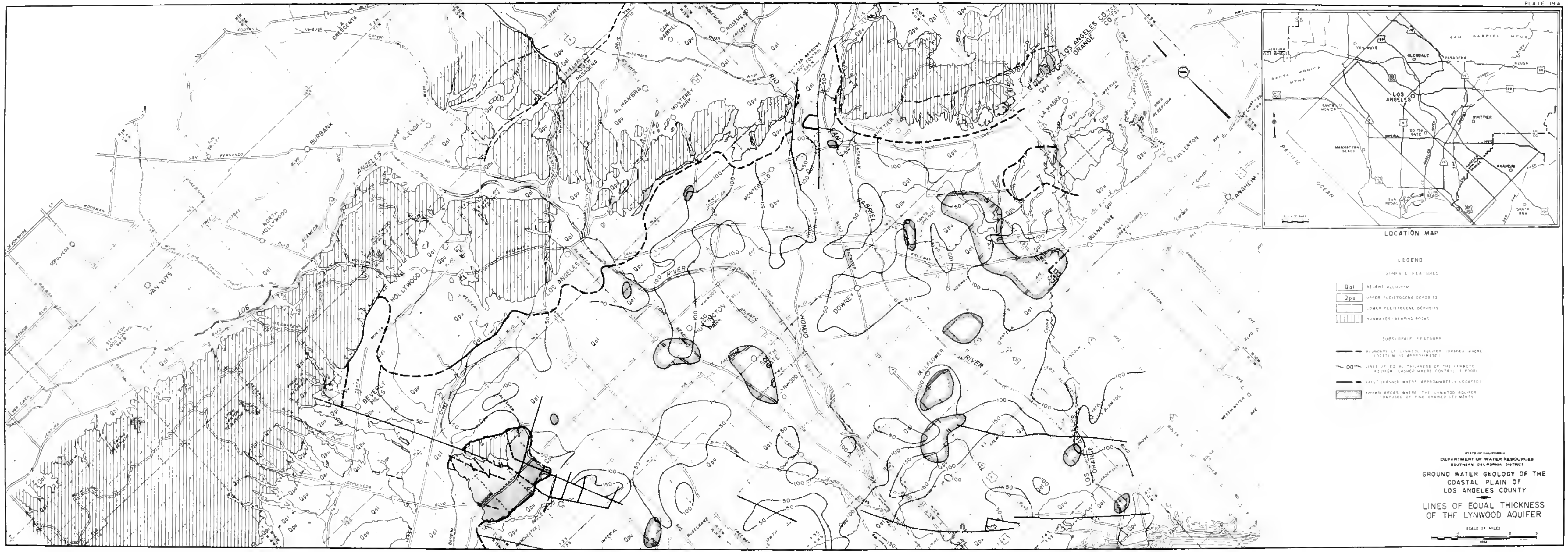
GROUND WATER GEOLOGY OF THE COASTAL PLAIN OF LOS ANGELES COUNTY

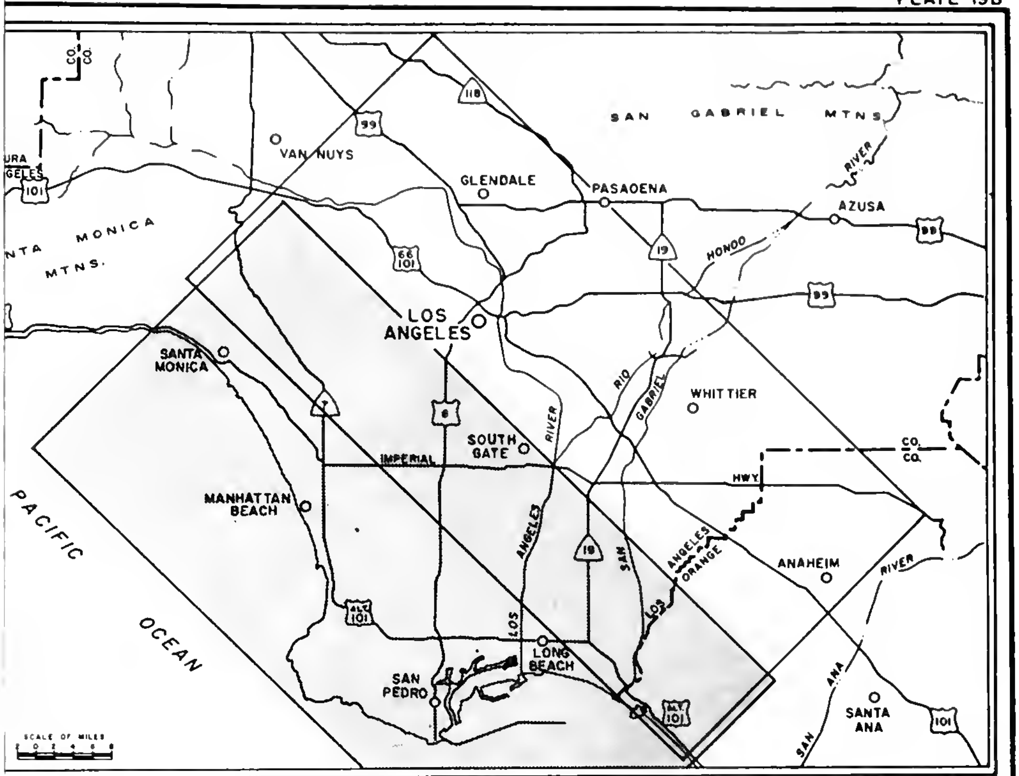
LINES OF EQUAL THICKNESS OF THE LYNWOOD AQUIFER

SCALE OF MILES

1 0 1 2 3

1961


VAN NUYS
BURBANK
GLENDALE
NORTH HOLLYWOOD
HOLLYWOOD
BEVERLY HILLS
LOS ANGELES
ALHAMBRA
MONTEREY PARK
SAN GABRIEL
ROSEMEAD
WHITTIER
LA HABRA
FULLERTON
ANAHEIM
BUENA PARK
DOWNEY
HUNTINGTON PARK
SOUTH GATE
LYNWOOD
BELLFLOWER
LOS ANGELES RIVER
SAN GABRIEL RIVER
RIO HONDO
LOS ANGELES CO.
ORANGE CO.
LOCATION MAP
PACIFIC OCEAN
SANTA MONICA
MANHATTAN BEACH
SAN PEDRO
LONG BEACH
PASADENA
AZUSA
SANTA ANA
LEGEND
SURFACE FEATURES
Qal RECENT ALLUVIUM
Qpu UPPER PLEISTOCENE DEPOSITS
LOWER PLEISTOCENE DEPOSITS
SUBSURFACE FEATURES
100
STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN CALIFORNIA DISTRICT
GROUND WATER GEOLOGY OF THE
COASTAL PLAIN OF
LOS ANGELES COUNTY
LINES OF EQUAL THICKNESS
OF THE LYNWOOD AQUIFER
SCALE OF MILES
0
2
3



LOCATION MAP

LEGEND

SURFACE FEATURES

- Qal — RECENT ALLUVIUM
- Qpu — UPPER PLEISTOCENE DEPOSITS
- LOWER PLEISTOCENE DEPOSITS
- NONWATER-BEARING ROCKS

SUBSURFACE FEATURES

- BOUNDARY OF LYNWOOD AQUIFER (DASHED WHERE LOCATION IS APPROXIMATE)
- —50— LINES OF EQUAL THICKNESS OF THE LYNWOOD AQUIFER (DASHED WHERE CONTROL IS POOR)
- FAULT (DASHED WHERE APPROXIMATELY LOCATED)
- KNOWN AREAS WHERE THE LYNWOOD AQUIFER IS COMPOSED OF FINE GRAINED SEDIMENTS

STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN CALIFORNIA DISTRICT

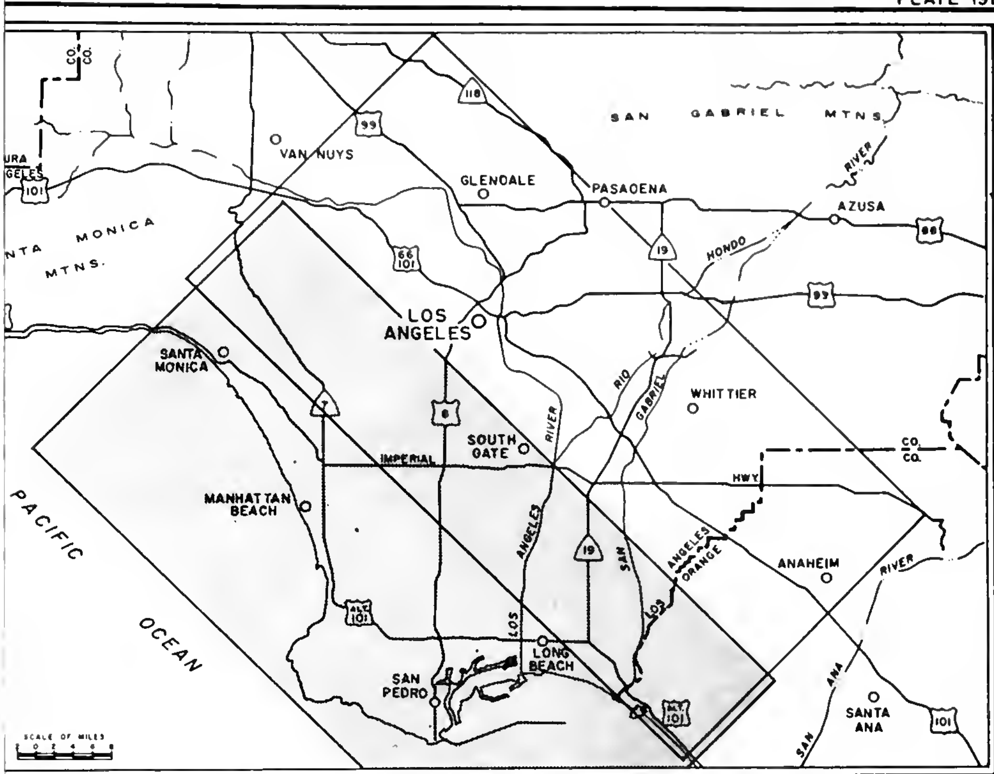
GROUND WATER GEOLOGY OF THE COASTAL PLAIN OF LOS ANGELES COUNTY

LINES OF EQUAL THICKNESS OF THE LYNWOOD AQUIFER

SCALE OF MILES

1 0 1 2 3

1961



LOCATION MAP

LEGEND

SURFACE FEATURES

Qal	RECENT ALLUVIUM
Qpu	UPPER PLEISTOCENE DEPOSITS
	LOWER PLEISTOCENE DEPOSITS
	NONWATER-BEARING ROCKS

SUBSURFACE FEATURES

BOUNDARY OF LYNWOOD AQUIFER (DASHED WHERE LOCATION IS APPROXIMATE)

—50— LINES OF EQUAL THICKNESS OF THE LYNWOOD AQUIFER (DASHED WHERE CONTROL IS POOR)

FAULT (DASHED WHERE APPROXIMATELY LOCATED)

KNOWN AREAS WHERE THE LYNWOOD AQUIFER IS COMPOSED OF FINE GRAINED SEDIMENTS

STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN CALIFORNIA DISTRICT

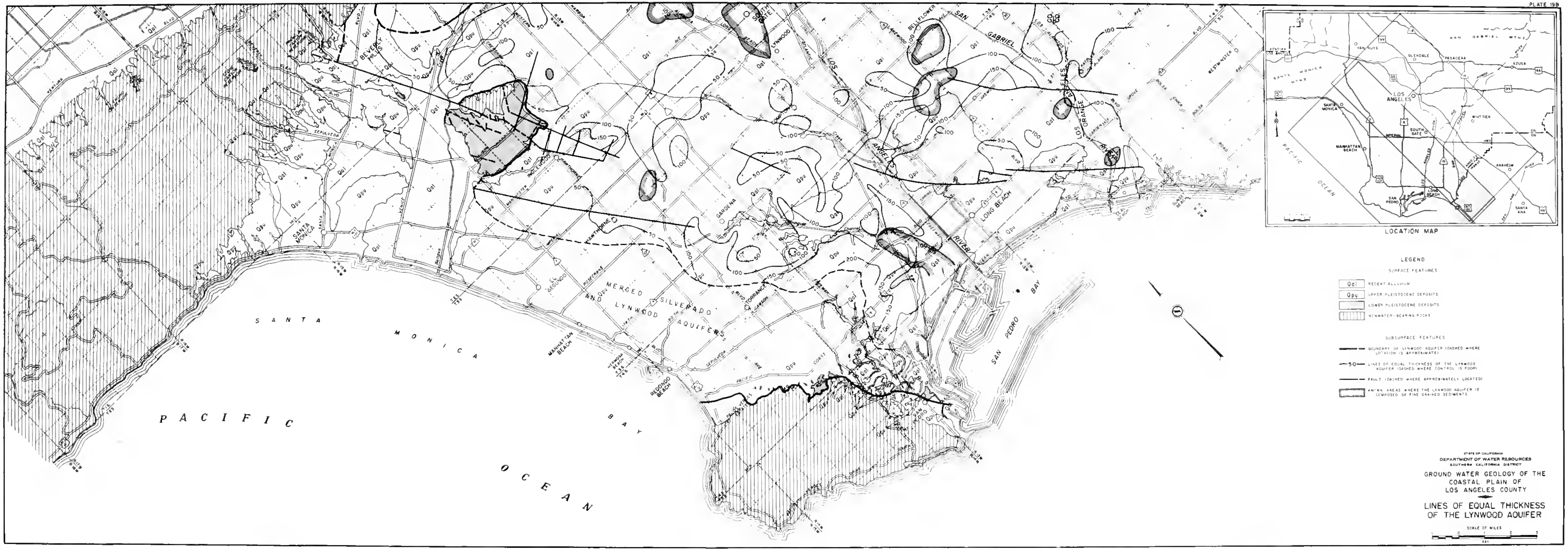
GROUND WATER GEOLOGY OF THE COASTAL PLAIN OF LOS ANGELES COUNTY

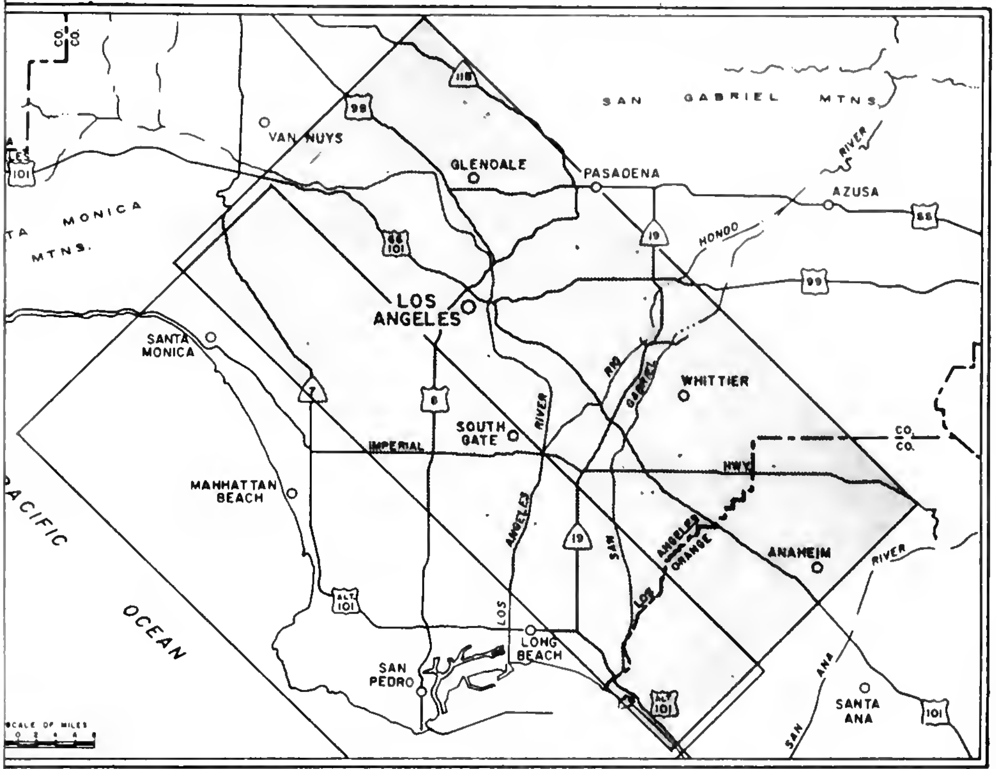
LINES OF EQUAL THICKNESS OF THE LYNWOOD AQUIFER

SCALE OF MILES

1 0 1 2 3

1961


SANTA MONICA
BEVERLY HILLS
INGLEWOOD
HAWTHORNE
GARDENA
TORRANCE
LYNWOOD
LONG BEACH
MANHATTAN BEACH
HERMOSA BEACH
REDONDO BEACH
SAN PEDRO
SAN GABRIEL
LOS ANGELES RIVER
MERGED SILVERADO AND LYNWOOD AQUIFERS
SANTA MONICA BAY
PACIFIC OCEAN
SAN PEDRO BAY
LOCATION MAP
LEGEND
SURFACE FEATURES
Qal RECENT ALLUVIUM
Qpu UPPER PLEISTOCENE DEPOSITS
LOWER PLEISTOCENE DEPOSITS
NONWATER-BEARING ROCKS
SUBSURFACE FEATURES
BOUNDARY OF LYNWOOD AQUIFER (DASHED WHERE LOCATION IS APPROXIMATE)
50 LINES OF EQUAL THICKNESS OF THE LYNWOOD AQUIFER (DASHED WHERE CONTROL IS POOR)
FAULT (DASHED WHERE APPROXIMATELY LOCATED)
AREAS WHERE THE LYNWOOD AQUIFER IS COMPOSED OF FINE GRAINED SEDIMENTS
STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN CALIFORNIA DISTRICT
GROUND WATER GEOLOGY OF THE COASTAL PLAIN OF LOS ANGELES COUNTY
LINES OF EQUAL THICKNESS OF THE LYNWOOD AQUIFER
SCALE OF MILES



LOCATION MAP

LEGEND

SURFACE FEATURES

Qal	RECENT ALLUVIUM
Qpu	UPPER PLEISTOCENE DEPOSITS
	LOWER PLEISTOCENE DEPOSITS
	NONWATER-BEARING ROCKS

SUBSURFACE FEATURES

	BOUNDARY OF SILVERADO AQUIFER (DASHED WHERE LOCATION IS APPROXIMATE)
-200	LINES OF EQUAL ELEVATION ON THE BASE OF THE SILVERADO AQUIFER (DASHED WHERE CONTROL IS POOR)
	FAULT (DASHED WHERE APPROXIMATELY LOCATED)
	KNOWN AREAS WHERE THE SILVERADO AQUIFER IS MERGED WITH THE OVERLYING AQUIFER

STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN CALIFORNIA DISTRICT

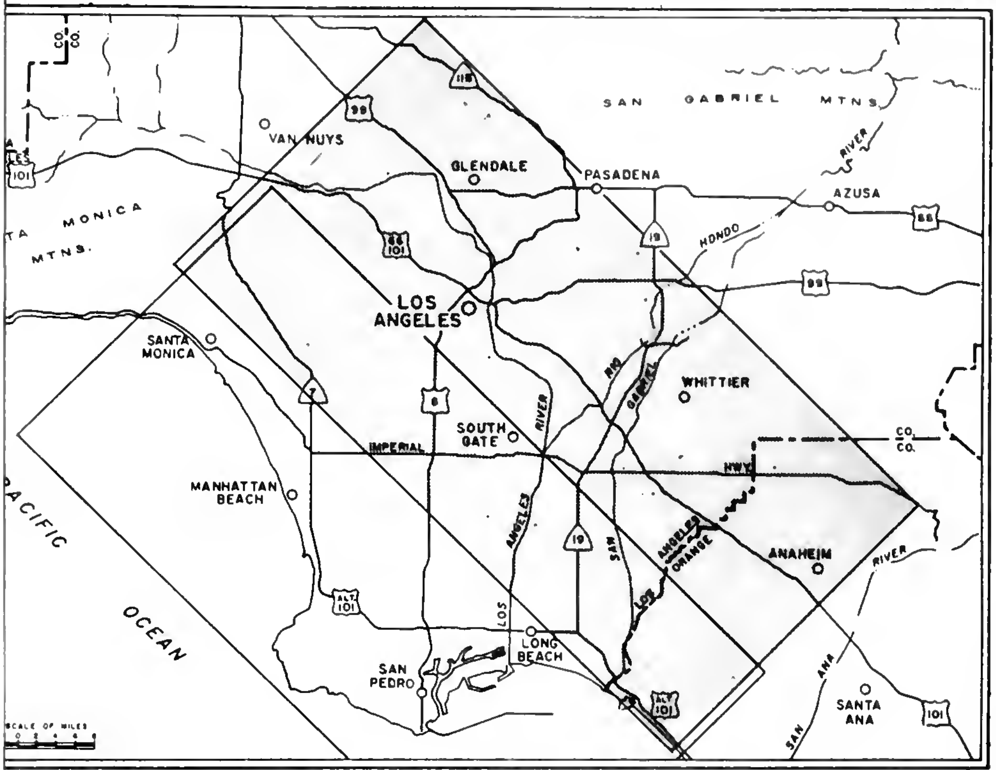
GROUND WATER GEOLOGY OF THE COASTAL PLAIN OF LOS ANGELES COUNTY

LINES OF EQUAL ELEVATION ON THE BASE OF THE SILVERADO AQUIFER

SCALE OF MILES

1 0 1 2 3

1961



LOCATION MAP

LEGEND

SURFACE FEATURES

Qal	RECENT ALLUVIUM
Qpu	UPPER PLEISTOCENE DEPOSITS
	LOWER PLEISTOCENE DEPOSITS
	NONWATER-BEARING ROCKS

SUBSURFACE FEATURES

	BOUNDARY OF SILVERADO AQUIFER (DASHED WHERE LOCATION IS APPROXIMATE)
-200	LINES OF EQUAL ELEVATION ON THE BASE OF THE SILVERADO AQUIFER (DASHED WHERE CONTROL IS POOR)
	FAULT (DASHED WHERE APPROXIMATELY LOCATED)
	KNOWN AREAS WHERE THE SILVERADO AQUIFER IS MERGED WITH THE OVERLYING AQUIFER

STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN CALIFORNIA DISTRICT

GROUND WATER GEOLOGY OF THE COASTAL PLAIN OF LOS ANGELES COUNTY

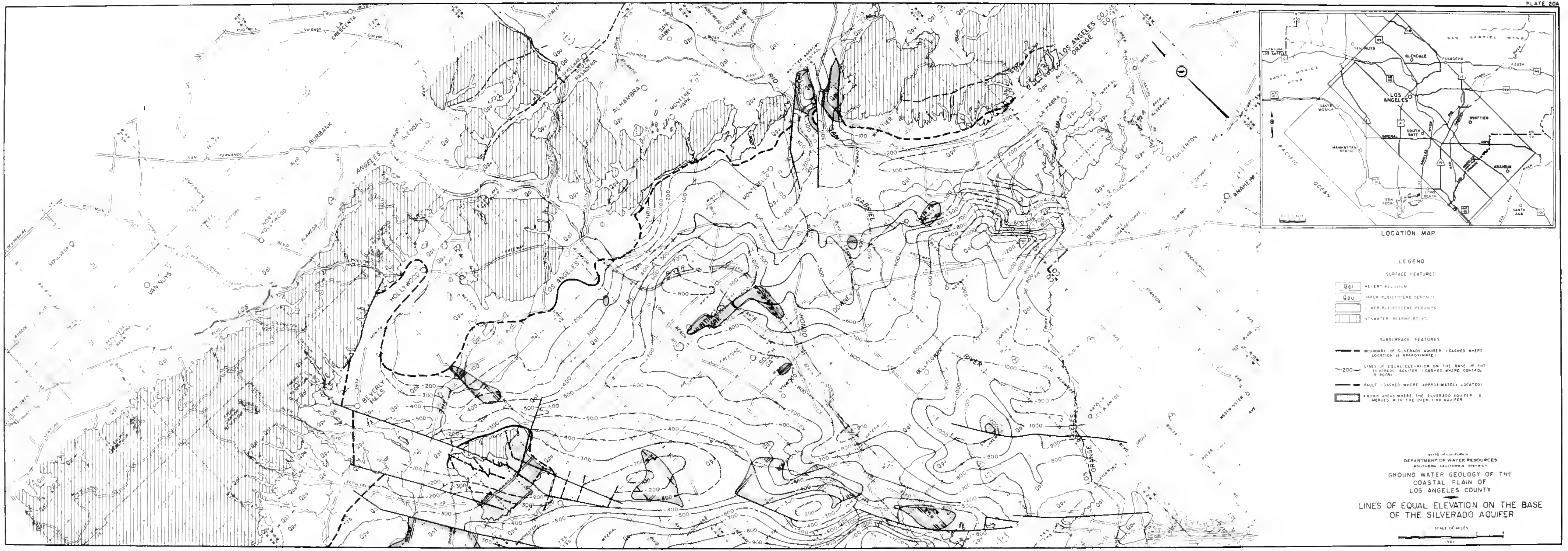
LINES OF EQUAL ELEVATION ON THE BASE OF THE SILVERADO AQUIFER

SCALE OF MILES

1 0 1 2 3

1961

PLATE 20A

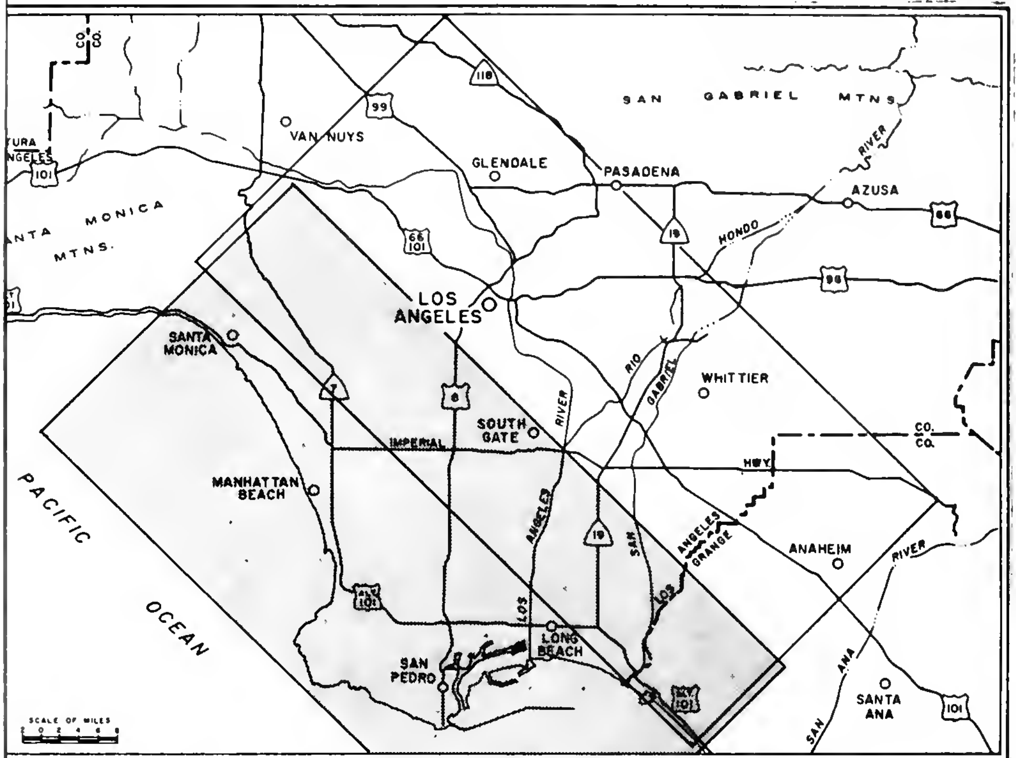


STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN CALIFORNIA DISTRICT

GROUND WATER GEOLOGY OF THE COASTAL PLAIN OF LOS ANGELES COUNTY

LINES OF EQUAL ELEVATION ON THE BASE OF THE SILVERADO AQUIFER

1961



LOCATION MAP

LEGEND

SURFACE FEATURES

Qal — RECENT ALLUVIUM

Qpu — UPPER PLEISTOCENE DEPOSITS

LOWER PLEISTOCENE DEPOSITS

NONWATER-BEARING ROCKS

SUBSURFACE FEATURES

BOUNDARY OF THE SILVERADO AQUIFER (DASHED WHERE LOCATION IS APPROXIMATE)

—700— LINES OF EQUAL ELEVATION ON THE BASE OF THE SILVERADO AQUIFER (DASHED WHERE CONTROL IS POOR)

FAULT (DASHED WHERE APPROXIMATELY LOCATED)

KNOWN AREAS WHERE THE SILVERADO AQUIFER IS MERGED WITH THE OVERLYING AQUIFER

STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN CALIFORNIA DISTRICT

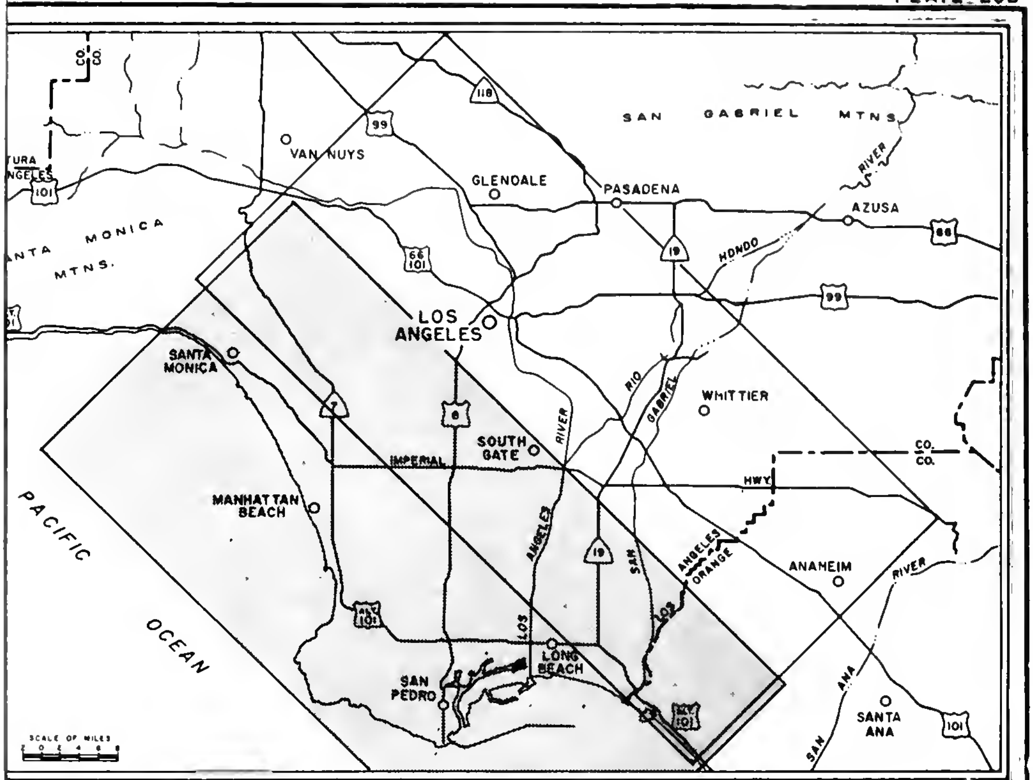
GROUND WATER GEOLOGY OF THE COASTAL PLAIN OF LOS ANGELES COUNTY

LINES OF EQUAL ELEVATION ON THE BASE OF THE SILVERADO AQUIFER

SCALE OF MILES

0 2 3

1961



LOCATION MAP

LEGEND

SURFACE FEATURES

Qal RECENT ALLUVIUM

Qpu UPPER PLEISTOCENE DEPOSITS

LOWER PLEISTOCENE DEPOSITS

NONWATER-BEARING ROCKS

SUBSURFACE FEATURES

BOUNDARY OF THE SILVERADO AQUIFER (DASHED WHERE LOCATION IS APPROXIMATE)

700 LINES OF EQUAL ELEVATION ON THE BASE OF THE SILVERADO AQUIFER (DASHED WHERE CONTROL IS POOR)

FAULT (DASHED WHERE APPROXIMATELY LOCATED)

KNOWN AREAS WHERE THE SILVERADO AQUIFER IS MERGED WITH THE OVERLYING AQUIFER

STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN CALIFORNIA DISTRICT

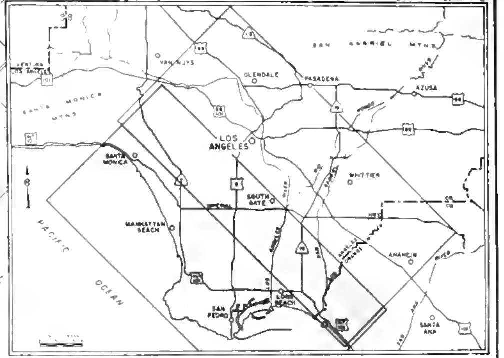
GROUND WATER GEOLOGY OF THE COASTAL PLAIN OF LOS ANGELES COUNTY

LINES OF EQUAL ELEVATION ON THE BASE OF THE SILVERADO AQUIFER

SCALE OF MILES

0 2 4

1961



LOCATION MAP

LEGEND

SURFACE FEATURES

- Qal RECENT ALLUVIUM
- Qpu UPPER PLEISTOCENE DEPOSITS
- LOWER PLEISTOCENE DEPOSITS
- NONWATER-BEARING ROCKS

SUBSURFACE FEATURES

- BOUNDARY OF THE SILVERADO AQUIFER (DASHED WHERE LOCATION IS APPROXIMATE)
- -700 LINES OF EQUAL ELEVATION ON THE BASE OF THE SILVERADO AQUIFER (DASHED WHERE CONTROL IS POOR)
- FAULT (DASHED WHERE APPROXIMATELY LOCATED)
- KNOWN AREAS WHERE THE SILVERADO AQUIFER IS MERGED WITH THE OVERLYING AQUIFER

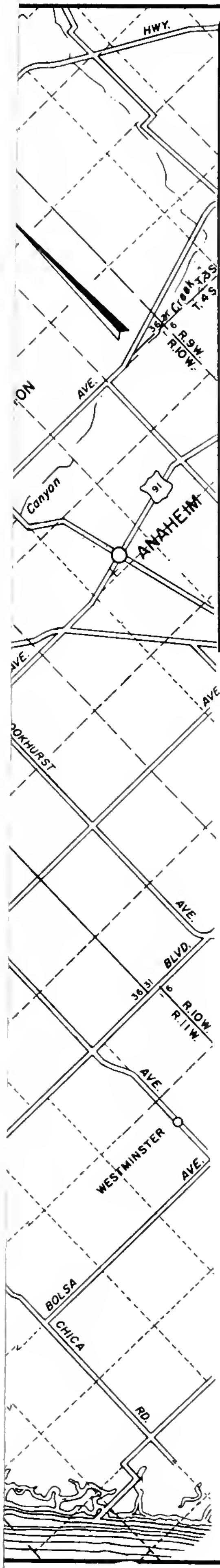
STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN CALIFORNIA DISTRICT

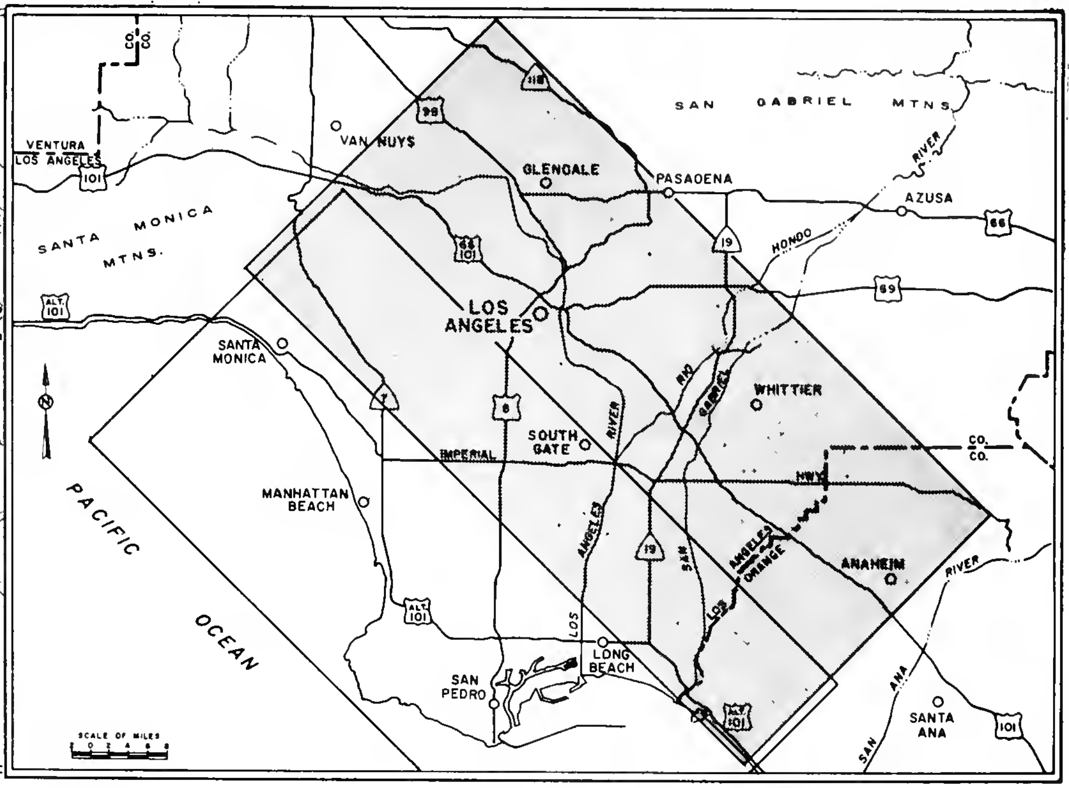
GROUND WATER GEOLOGY OF THE COASTAL PLAIN OF LOS ANGELES COUNTY

LINES OF EQUAL ELEVATION ON THE BASE OF THE SILVERADO AQUIFER

SCALE OF MILES

1961





LOCATION MAP

LEGEND

SURFACE FEATURES

Qal RECENT ALLUVIUM

Qpu UPPER PLEISTOCENE DEPOSITS

LOWER PLEISTOCENE DEPOSITS

NONWATER-BEARING ROCKS

SUBSURFACE FEATURES

BOUNDARY OF SILVERADO AQUIFER (DASHED WHERE LOCATION IS APPROXIMATE)

—100— LINES OF EQUAL THICKNESS ON THE BASE OF THE SILVERADO AQUIFER (DASHED WHERE CONTROL IS POOR)

FAULT (DASHED WHERE APPROXIMATELY LOCATED)

KNOWN AREAS WHERE THE SILVERADO AQUIFER IS COMPOSED OF FINE GRAINED SEDIMENTS

STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN CALIFORNIA DISTRICT

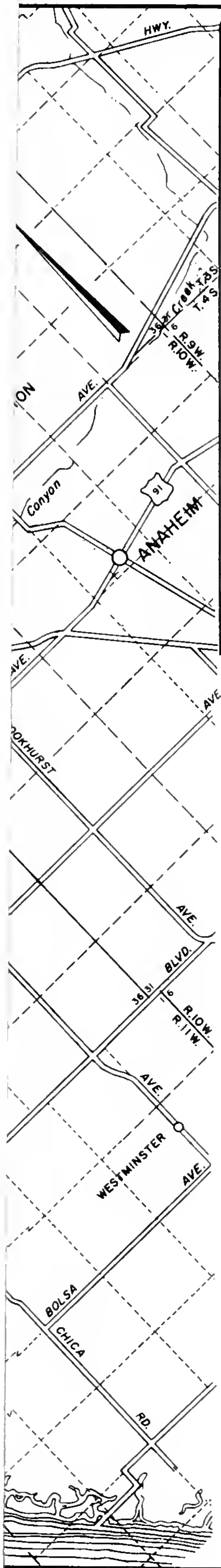
GROUND WATER GEOLOGY OF THE COASTAL PLAIN OF LOS ANGELES COUNTY

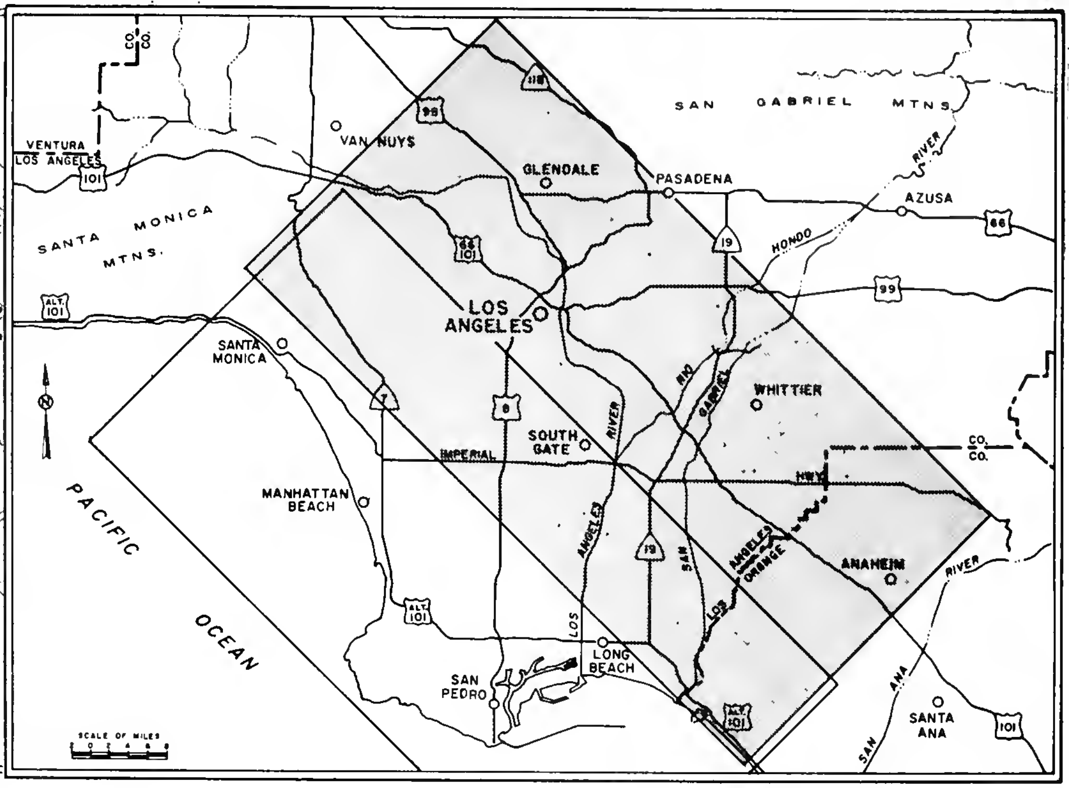
LINES OF EQUAL THICKNESS OF THE SILVERADO AQUIFER

SCALE OF MILES

1 0 1 2 3

1961





LOCATION MAP

LEGEND

SURFACE FEATURES

Qal	RECENT ALLUVIUM
Qpu	UPPER PLEISTOCENE DEPOSITS
	LOWER PLEISTOCENE DEPOSITS
	NONWATER-BEARING ROCKS

SUBSURFACE FEATURES

BOUNDARY OF SILVERADO AQUIFER (DASHED WHERE LOCATION IS APPROXIMATE)

—100— LINES OF EQUAL THICKNESS ON THE BASE OF THE SILVERADO AQUIFER (DASHED WHERE CONTROL IS POOR)

FAULT (DASHED WHERE APPROXIMATELY LOCATED)

KNOWN AREAS WHERE THE SILVERADO AQUIFER IS COMPOSED OF FINE GRAINED SEDIMENTS

STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN CALIFORNIA DISTRICT

GROUND WATER GEOLOGY OF THE COASTAL PLAIN OF LOS ANGELES COUNTY

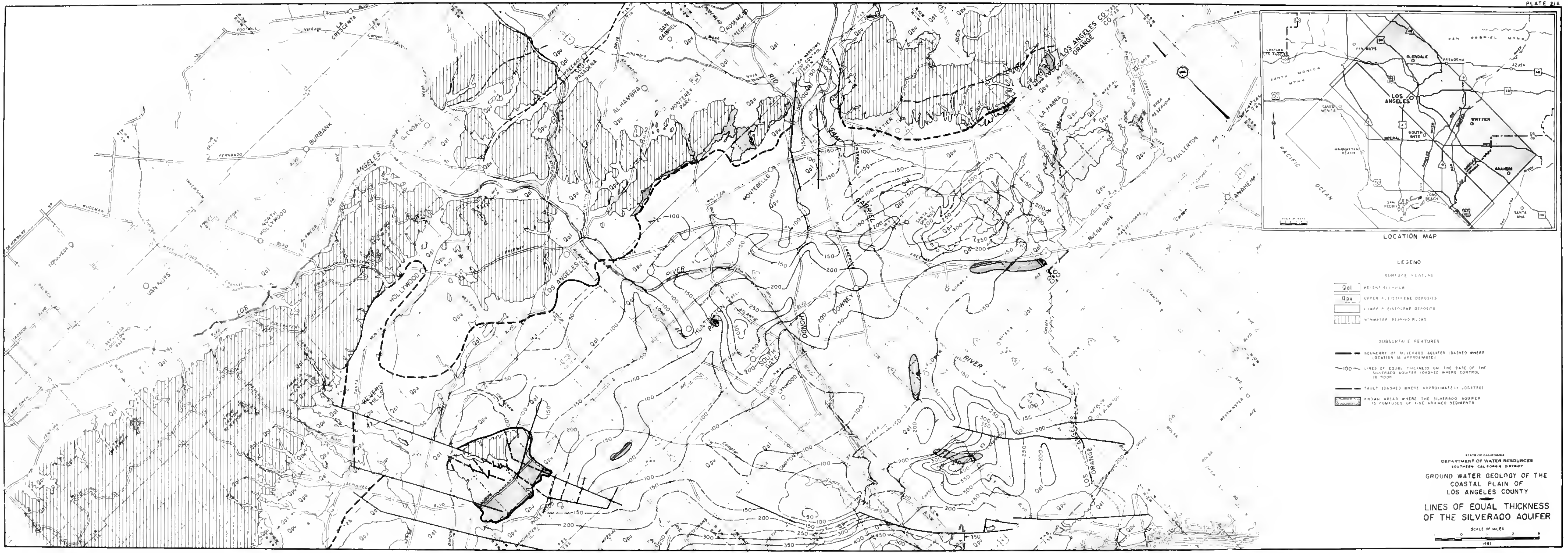
LINES OF EQUAL THICKNESS OF THE SILVERADO AQUIFER

SCALE OF MILES

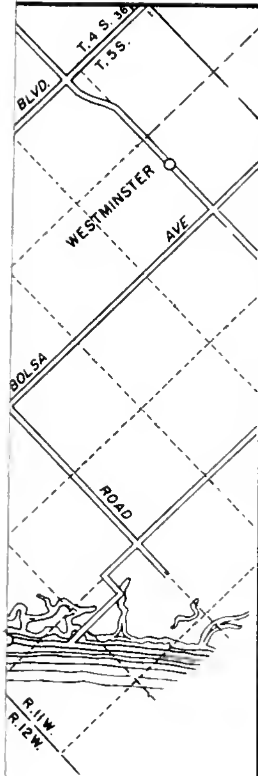
1 0 1 2 3

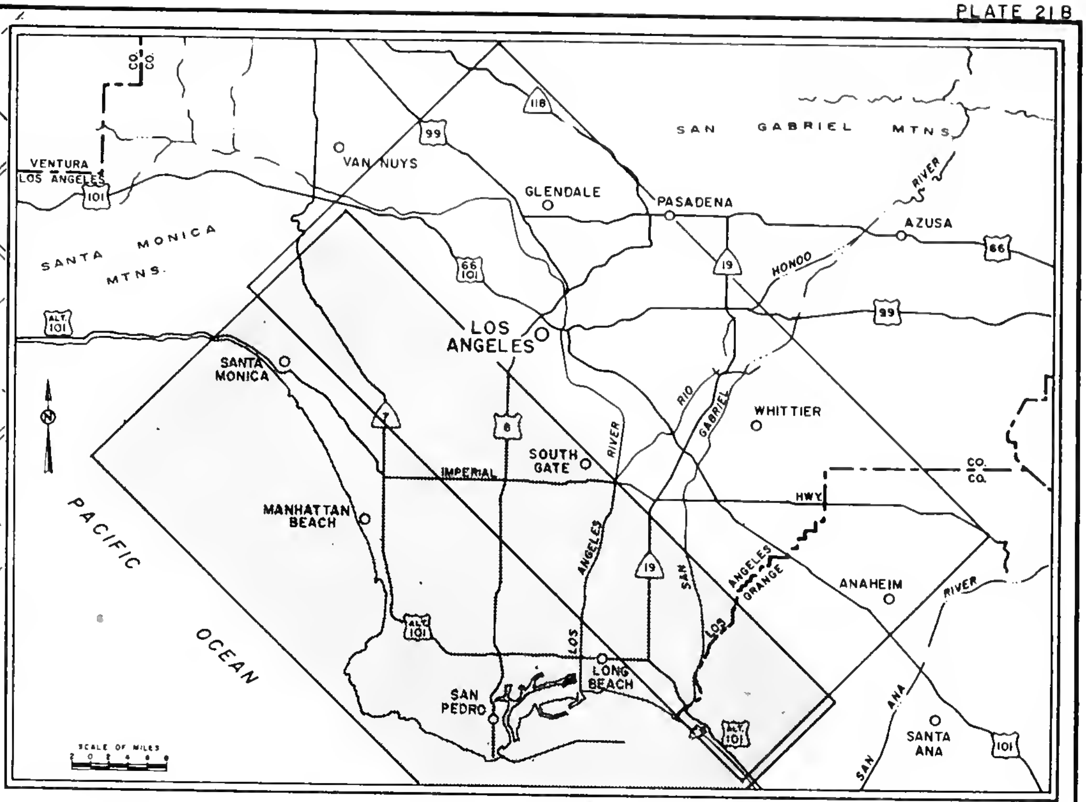
1961

PLATE 21A



LOCATION MAP
LEGEND
SURFACE FEATURE
Qal RECENT ALLUVIUM
Qpu UPPER PLEISTOCENE DEPOSITS
LOWER PLEISTOCENE DEPOSITS
NONWATER BEARING ROCKS
SUBSURFACE FEATURES
BOUNDARY OF SILVERADO AQUIFER (DASHED WHERE LOCATION IS APPROXIMATE)
100 LINES OF EQUAL THICKNESS ON THE BASE OF THE SILVERADO AQUIFER (DASHED WHERE CONTROL IS POOR)
FAULT (DASHED WHERE APPROXIMATELY LOCATED)
KNOWN AREAS WHERE THE SILVERADO AQUIFER IS COMPOSED OF FINE GRAINED SEDIMENTS
STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN CALIFORNIA DISTRICT
GROUND WATER GEOLOGY OF THE COASTAL PLAIN OF LOS ANGELES COUNTY
LINES OF EQUAL THICKNESS OF THE SILVERADO AQUIFER
SCALE OF MILES
1961
LOS ANGELES
BURBANK
GLENDALE
VAN NUYS
NORTH HOLLYWOOD
HOLLYWOOD
BEVERLY HILLS
ALHAMBRA
MONTEREY PARK
MONTEBELLO
DOWNEY
SOUTH GATE
LYNWOOD
WHITTIER
LA HABRA
FULLERTON
ANAHEIM
BUENA PARK
PACIFIC OCEAN





LOCATION MAP

LEGEND

SURFACE FEATURES

Qal	RECENT ALLUVIUM
Qpu	UPPER PLEISTOCENE DEPOSITS
	LOWER PLEISTOCENE DEPOSITS
	NONWATER-BEARING ROCKS

SUBSURFACE FEATURES

BOUNDARY OF SILVERADO AQUIFER (DASHED WHERE LOCATION IS APPROXIMATE)

—50— LINES OF EQUAL THICKNESS OF THE SILVERADO AQUIFER (DASHED WHERE CONTROL IS POOR)

FAULT (DASHED WHERE APPROXIMATELY LOCATED)

KNOWN AREAS WHERE THE SILVERADO AQUIFER IS COMPOSED OF FINE GRAINED SEDIMENTS

STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN CALIFORNIA DISTRICT

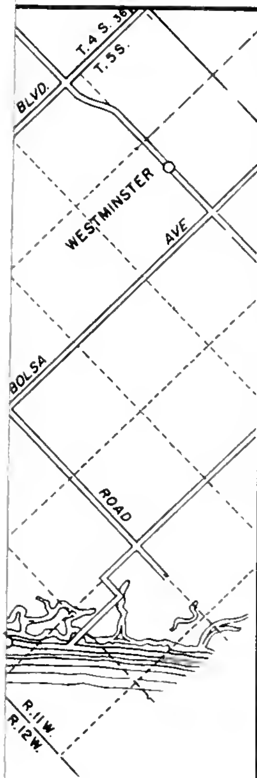
GROUND WATER GEOLOGY OF THE COASTAL PLAIN OF LOS ANGELES COUNTY

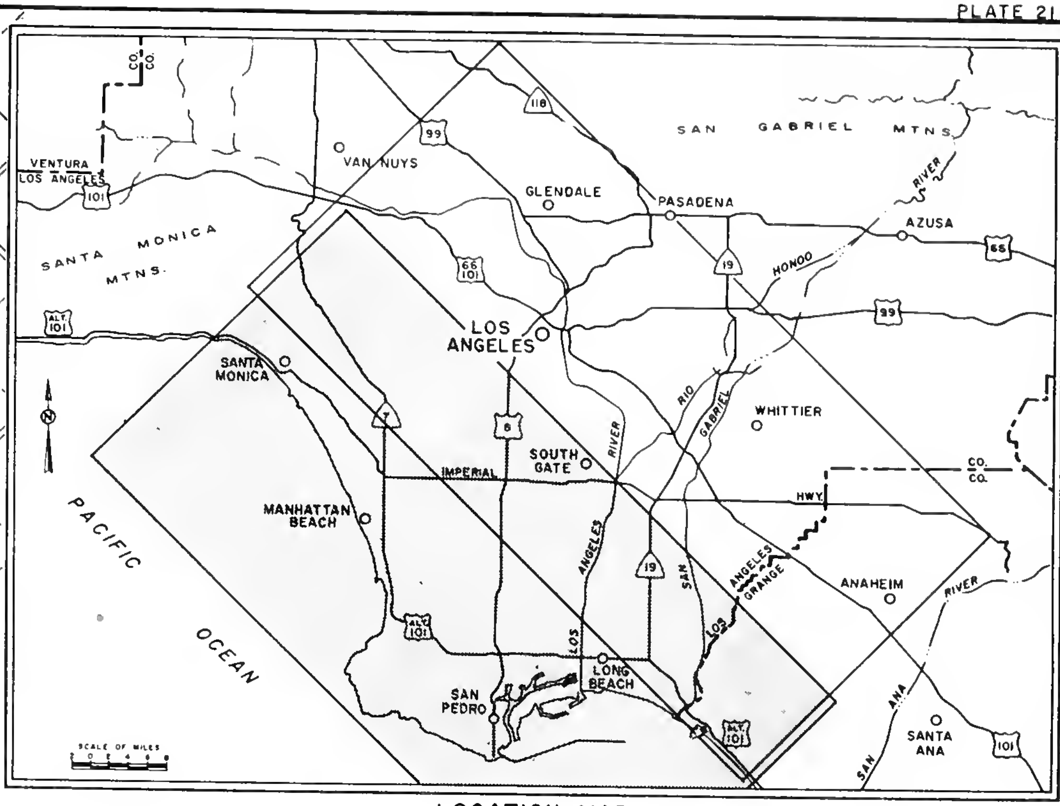
LINES OF EQUAL THICKNESS OF THE SILVERADO AQUIFER

SCALE OF MILES

1 0 1 2 3

1961





LOCATION MAP

LEGEND

SURFACE FEATURES

Qal	RECENT ALLUVIUM
Qpu	UPPER PLEISTOCENE DEPOSITS
	LOWER PLEISTOCENE DEPOSITS
	NONWATER-BEARING ROCKS

SUBSURFACE FEATURES

	BOUNDARY OF SILVERADO AQUIFER (DASHED WHERE LOCATION IS APPROXIMATE)
50	LINES OF EQUAL THICKNESS OF THE SILVERADO AQUIFER (DASHED WHERE CONTROL IS POOR)
	FAULT (DASHED WHERE APPROXIMATELY LOCATED)
	KNOWN AREAS WHERE THE SILVERADO AQUIFER IS COMPOSED OF FINE GRAINED SEDIMENTS

STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN CALIFORNIA DISTRICT

GROUND WATER GEOLOGY OF THE COASTAL PLAIN OF LOS ANGELES COUNTY

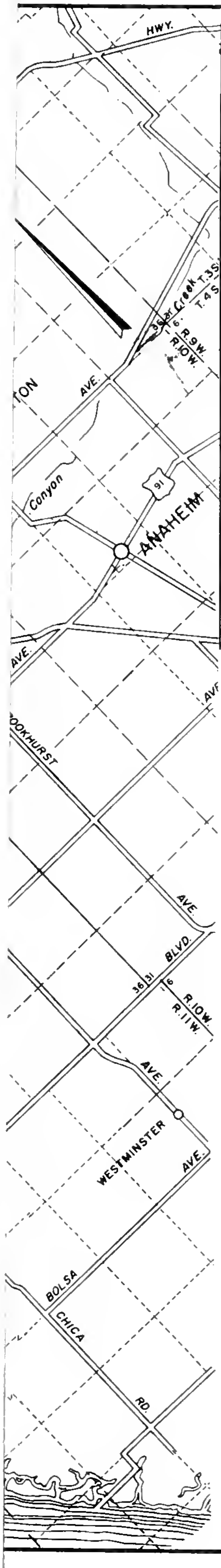
LINES OF EQUAL THICKNESS OF THE SILVERADO AQUIFER

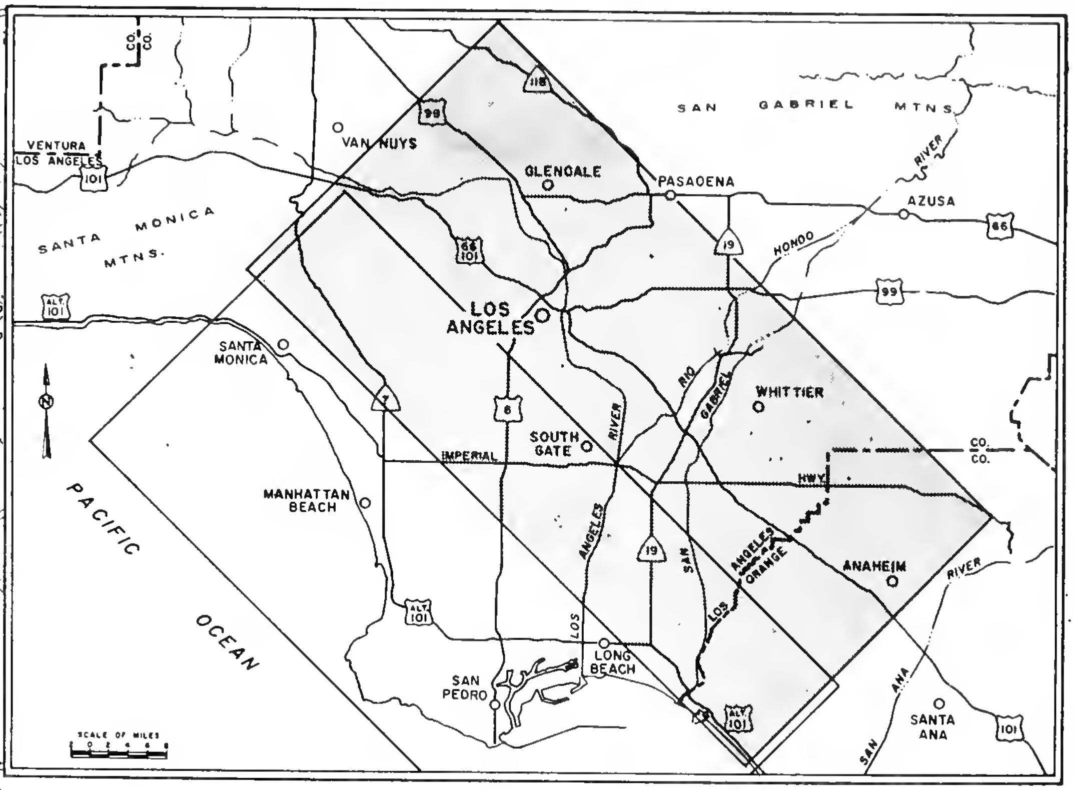
SCALE OF MILES

1 0 1 2 3

1961


SANTA MONICA BAY
PACIFIC OCEAN
SAN PEDRO BAY
MERGED SILVERADO AND LYNWOOD AQUIFERS
LOS ANGELES RIVER
SAN GABRIEL RIVER
LONG BEACH
GARDENA
HAWTHORNE
TORRANCE
SANTA MONICA
MANHATTAN BEACH
HERMOSA BEACH
REDONDO BEACH
BEVERLY HILLS
SOUTH GATE
LYNWOOD
COMPTON
LOCATION MAP
LOS ANGELES
PACIFIC OCEAN
SAN GABRIEL MTNS
SANTA MONICA MTNS
LEGEND
SURFACE FEATURES
Qal
Qpu
SUBSURFACE FEATURES
50
STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN CALIFORNIA DISTRICT
GROUND WATER GEOLOGY OF THE COASTAL PLAIN OF LOS ANGELES COUNTY
LINES OF EQUAL THICKNESS OF THE SILVERADO AOUIFER
SCALE OF MILES





LOCATION MAP

LEGEND

SURFACE FEATURES

Qal	RECENT ALLUVIUM
Qpu	UPPER PLEISTOCENE DEPOSITS
	LOWER PLEISTOCENE DEPOSITS
	NONWATER-BEARING ROCKS

SUBSURFACE FEATURES

BOUNDARY OF THE SUNNYSIDE AQUIFER (DASHED WHERE LOCATION IS APPROXIMATE)

—100— LINES OF EQUAL ELEVATION ON THE BASE OF THE SUNNYSIDE AQUIFER (DASHED WHERE CONTROL IS POOR)

FAULT (DASHED WHERE APPROXIMATELY LOCATED)

KNOWN AREAS WHERE THE SUNNYSIDE AQUIFER IS MERGED WITH THE OVERLYING AQUIFER

STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN CALIFORNIA DISTRICT

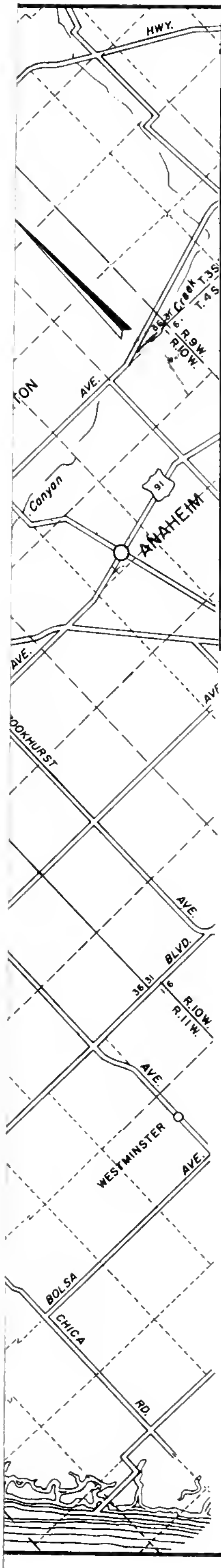
GROUND WATER GEOLOGY OF THE COASTAL PLAIN OF LOS ANGELES COUNTY

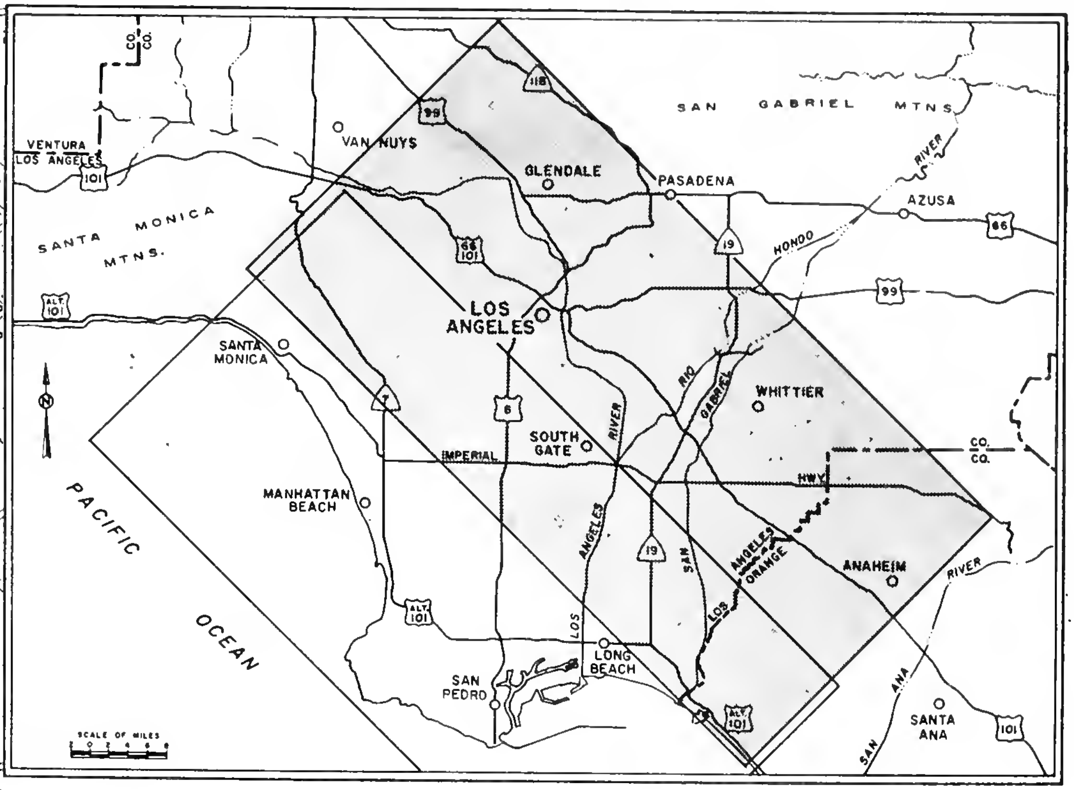
LINES OF EQUAL ELEVATION ON THE BASE OF THE SUNNYSIDE AQUIFER

SCALE OF MILES

1 0 1 2 3

1961





LOCATION MAP

LEGEND

SURFACE FEATURES

Qal	RECENT ALLUVIUM
Qpu	UPPER PLEISTOCENE DEPOSITS
	LOWER PLEISTOCENE DEPOSITS
	NONWATER-BEARING ROCKS

SUBSURFACE FEATURES

BOUNDARY OF THE SUNNYSIDE AQUIFER (DASHED WHERE LOCATION IS APPROXIMATE)

-100- LINES OF EQUAL ELEVATION ON THE BASE OF THE SUNNYSIDE AQUIFER (DASHED WHERE CONTROL IS POOR)

FAULT (DASHED WHERE APPROXIMATELY LOCATED)

KNOWN AREAS WHERE THE SUNNYSIDE AQUIFER IS MERGED WITH THE OVERLYING AQUIFER

STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN CALIFORNIA DISTRICT

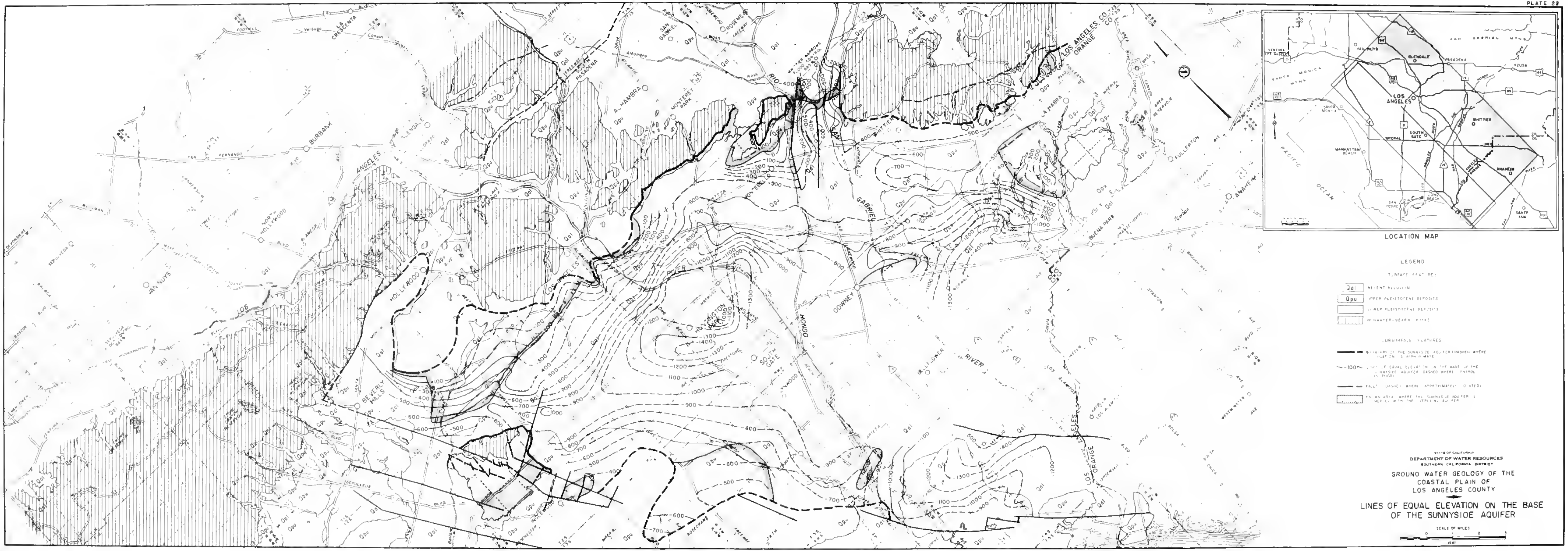
GROUND WATER GEOLOGY OF THE COASTAL PLAIN OF LOS ANGELES COUNTY

LINES OF EQUAL ELEVATION ON THE BASE OF THE SUNNYSIDE AQUIFER

SCALE OF MILES

1 0 1 2 3

1961

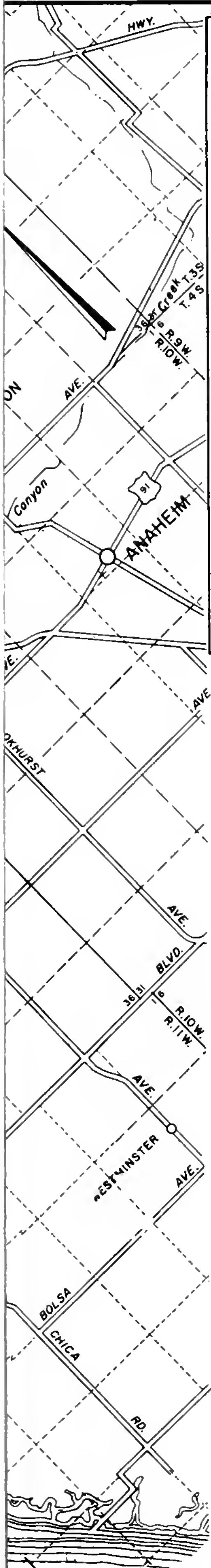


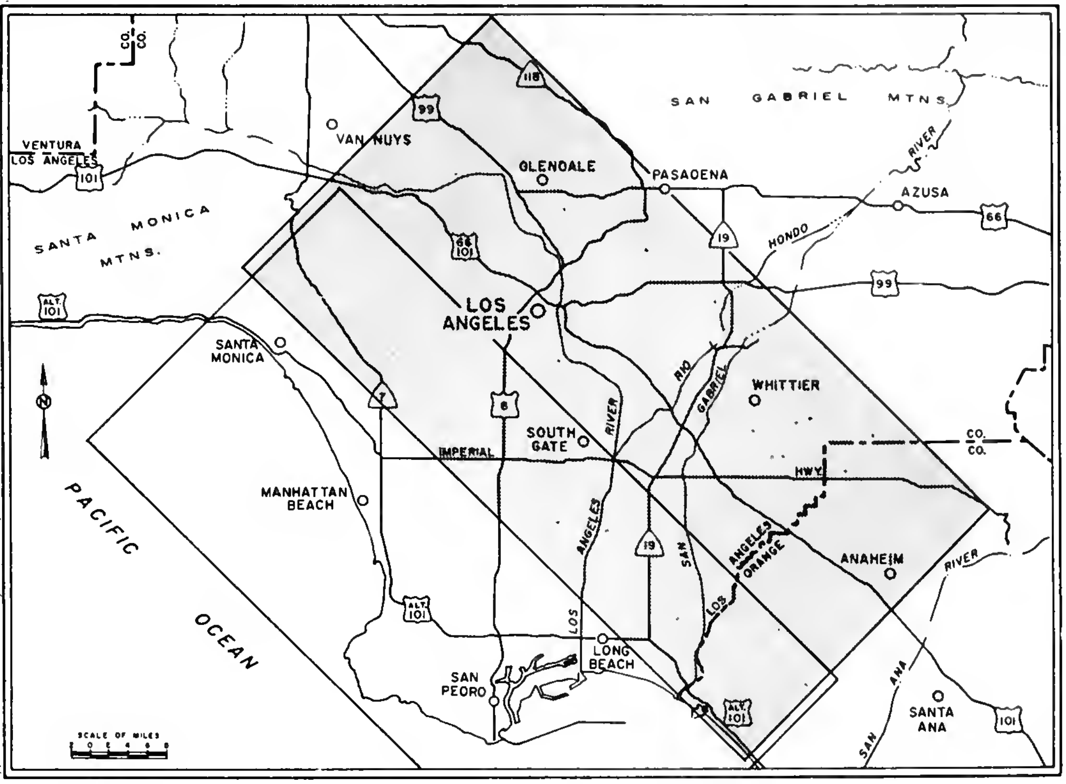
STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN CALIFORNIA DISTRICT

GROUND WATER GEOLOGY OF THE COASTAL PLAIN OF LOS ANGELES COUNTY

LINES OF EQUAL ELEVATION ON THE BASE OF THE SUNNYSIOE AQUIFER

1961





LOCATION MAP

LEGEND

SURFACE FEATURES

Qal	RECENT ALLUVIUM
Qpu	UPPER PLEISTOCENE DEPOSITS
	LOWER PLEISTOCENE DEPOSITS
	NONWATER-BEARING ROCKS

SUBSURFACE FEATURES

	BOUNDARY OF SUNNYSIDE AQUIFER (DASHED WHERE LOCATION IS APPROXIMATE)
150	LINES OF EQUAL THICKNESS OF THE SUNNYSIDE AQUIFER (DASHED WHERE CONTROL IS POOR)
	FAULT (DASHED WHERE APPROXIMATELY LOCATED)
	KNOWN AREAS WHERE THE SUNNYSIDE AQUIFER IS COMPOSED OF FINE GRAINED SEDIMENTS

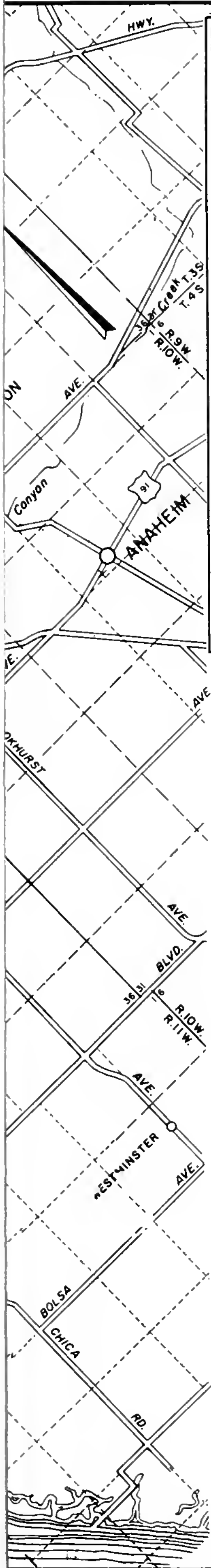
STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN CALIFORNIA DISTRICT

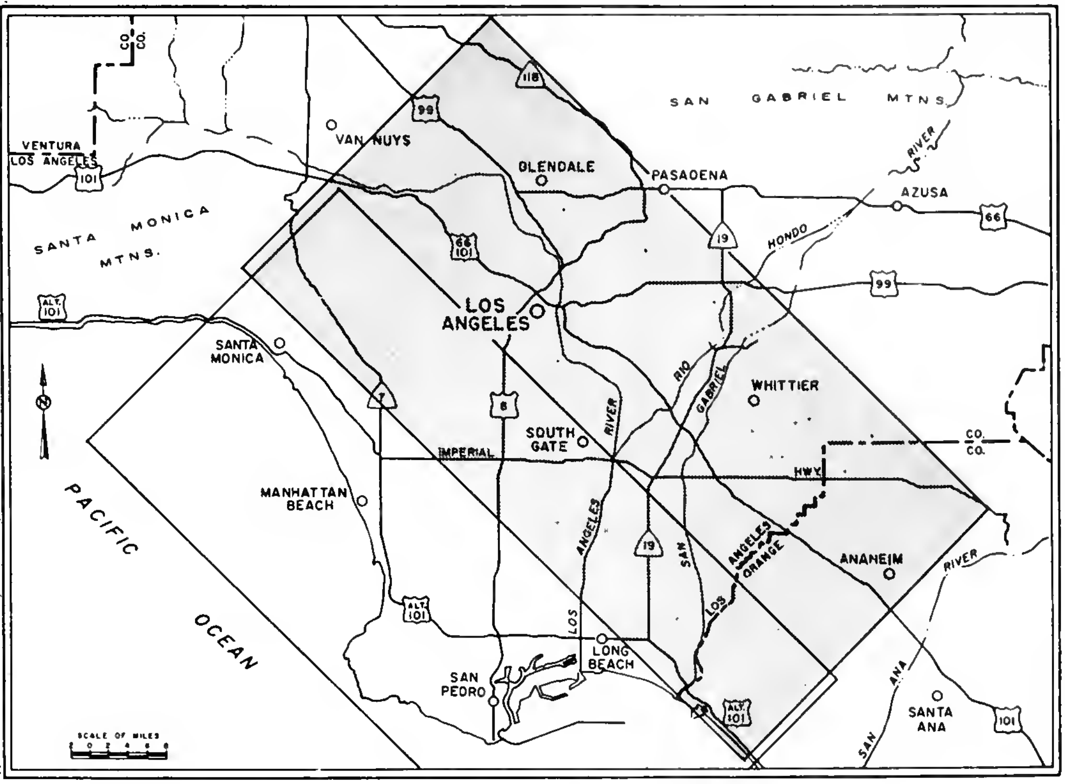
GROUND WATER GEOLOGY OF THE COASTAL PLAIN OF LOS ANGELES COUNTY

LINES OF EQUAL THICKNESS OF THE SUNNYSIDE AQUIFER

SCALE OF MILES
1 0 1 2 3

1961





LOCATION MAP

LEGEND

SURFACE FEATURES

Qal RECENT ALLUVIUM

Qpu UPPER PLEISTOCENE DEPOSITS

LOWER PLEISTOCENE DEPOSITS

NONWATER-BEARING ROCKS

SUBSURFACE FEATURES

BOUNDARY OF SUNNYSIDE AQUIFER (DASHED WHERE LOCATION IS APPROXIMATE)

~150~ LINES OF EQUAL THICKNESS OF THE SUNNYSIDE AQUIFER (DASHED WHERE CONTROL IS POOR)

FAULT (DASHED WHERE APPROXIMATELY LOCATED)

KNOWN AREAS WHERE THE SUNNYSIDE AQUIFER IS COMPOSED OF FINE GRAINED SEDIMENTS

STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN CALIFORNIA DISTRICT

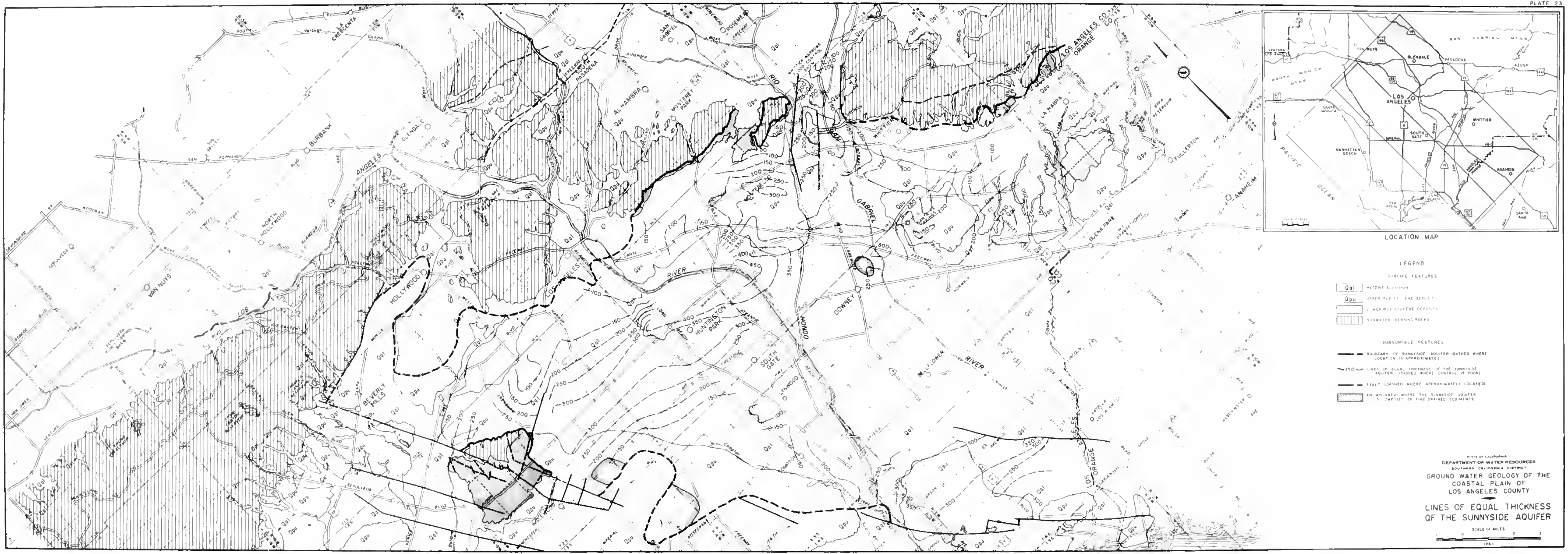
GROUND WATER GEOLOGY OF THE COASTAL PLAIN OF LOS ANGELES COUNTY

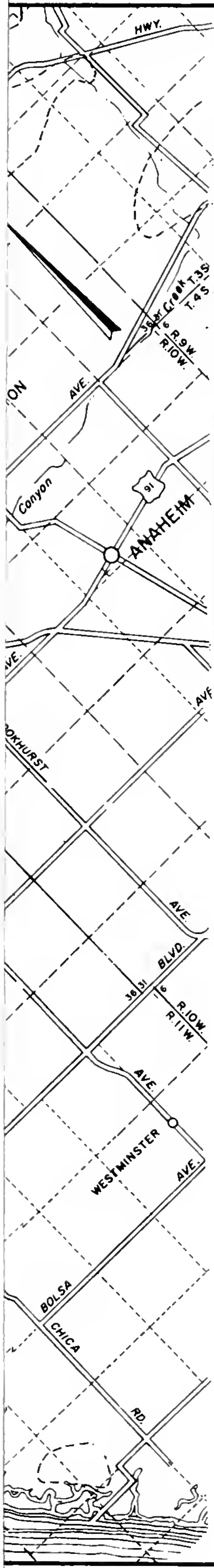
LINES OF EQUAL THICKNESS OF THE SUNNYSIDE AQUIFER

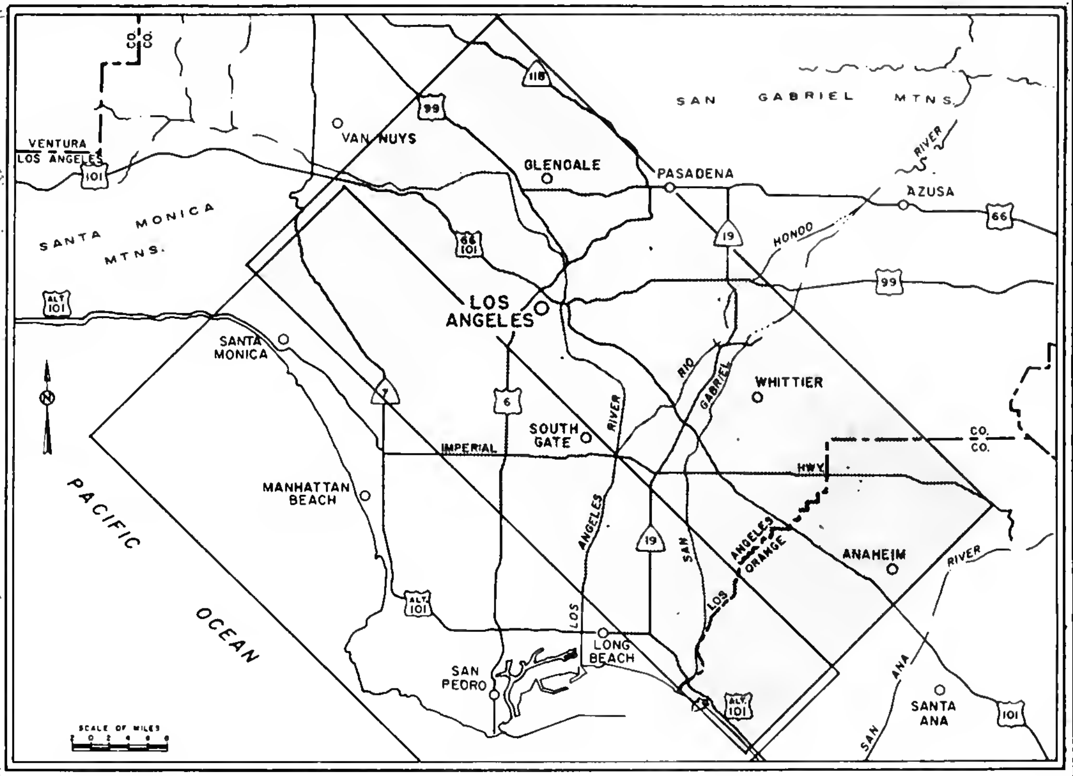
SCALE OF MILES
1 0 1 2 3

1961

PLATE 23


LOCATION MAP
LEGEND
SURFACE FEATURES
Qal
Qpu
NONWATER BEARING ROCKS
SUBSURFACE FEATURES
BOUNDARY OF SUNNYSIDE AQUIFER (DASHED WHERE LOCATION IS APPROXIMATE)
150
FAULT (DASHED WHERE APPROXIMATELY LOCATED)
STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN CALIFORNIA DISTRICT
GROUND WATER GEOLOGY OF THE
COASTAL PLAIN OF
LOS ANGELES COUNTY
LINES OF EQUAL THICKNESS
OF THE SUNNYSIDE AQUIFER
SCALE OF MILES
1961





LOCATION MAP

LEGEND

SURFACE FEATURES

Qal	RECENT ALLUVIUM
Qpu	UPPER PLEISTOCENE DEPOSITS
	LOWER PLEISTOCENE DEPOSITS
	NONWATER-BEARING ROCKS

SUBSURFACE FEATURES

--400—	LINES OF EQUAL ELEVATION ON THE BASE OF PRINCIPLE FRESH WATER-BEARING SEDIMENTS (DASHED WHERE CONTROL IS POOR)
o -50	KNOWN ELEVATION OF BASE OF FRESH WATER AT A WELL
o (-700)	MINIMUM ELEVATION OF FRESH WATER AT A WELL (BASE IS AT A GREATER DEPTH)
	FAULT (DASHED WHERE APPROXIMATELY LOCATED)
	OIL FIELDS (BOUNDARIES APPROXIMATE)

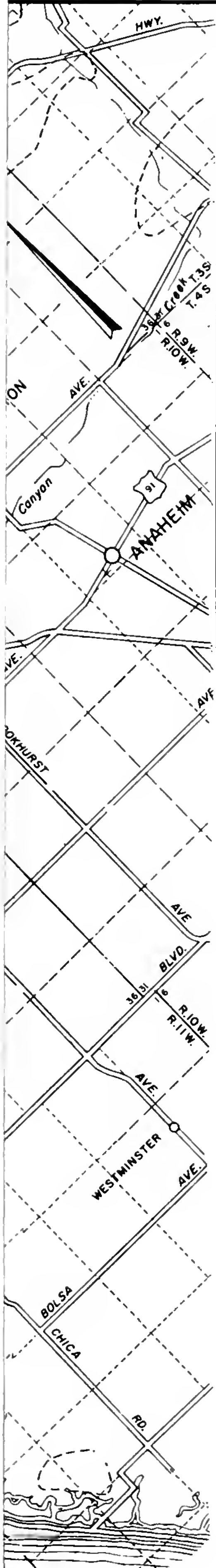
STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN CALIFORNIA DISTRICT

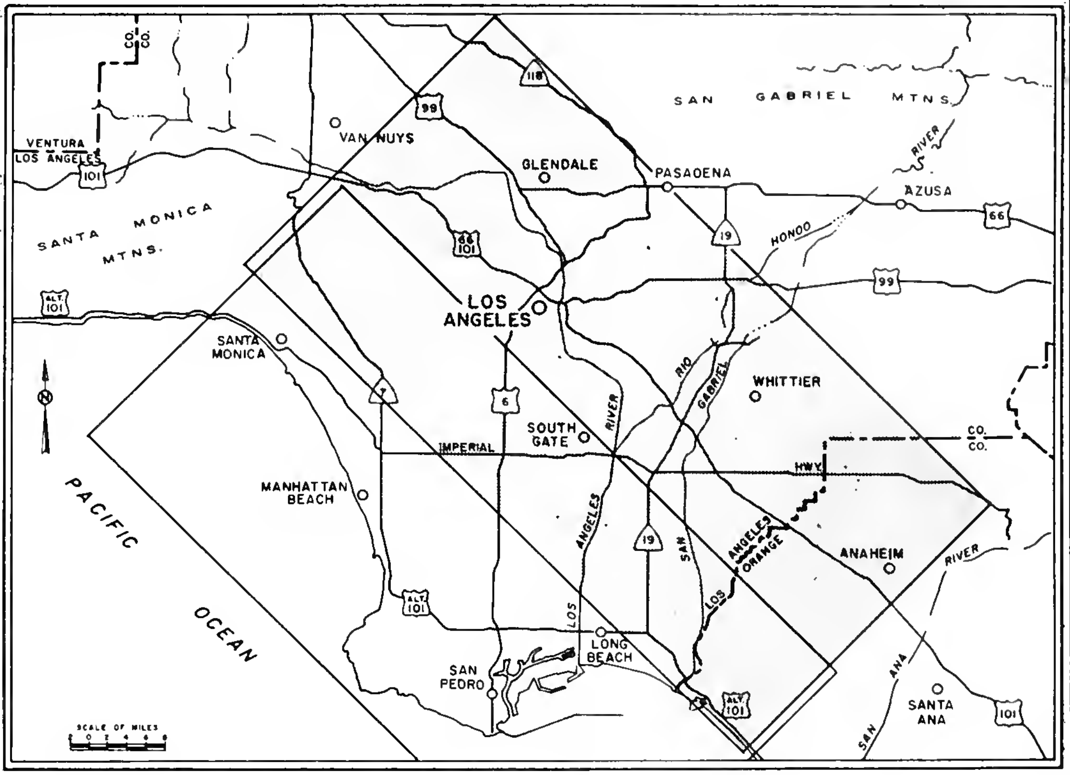
GROUND WATER GEOLOGY OF THE COASTAL PLAIN OF LOS ANGELES COUNTY

LINES OF EQUAL ELEVATION ON THE BASE OF FRESH WATER-BEARING SEDIMENTS

SCALE OF MILES
1 0 1 2 3

1961





LOCATION MAP

LEGEND

SURFACE FEATURES

Qal	RECENT ALLUVIUM
Qpu	UPPER PLEISTOCENE DEPOSITS
	LOWER PLEISTOCENE DEPOSITS
	NONWATER-BEARING ROCKS

SUBSURFACE FEATURES

--400—	LINES OF EQUAL ELEVATION ON THE BASE OF PRINCIPLE FRESH WATER-BEARING SEDIMENTS (DASHED WHERE CONTROL IS POOR)
o -50	KNOWN ELEVATION OF BASE OF FRESH WATER AT A WELL
o (-700)	MINIMUM ELEVATION OF FRESH WATER AT A WELL (BASE IS AT A GREATER DEPTH)
—— —	FAULT (DASHED WHERE APPROXIMATELY LOCATED)
	OIL FIELDS (BOUNDARIES APPROXIMATE)

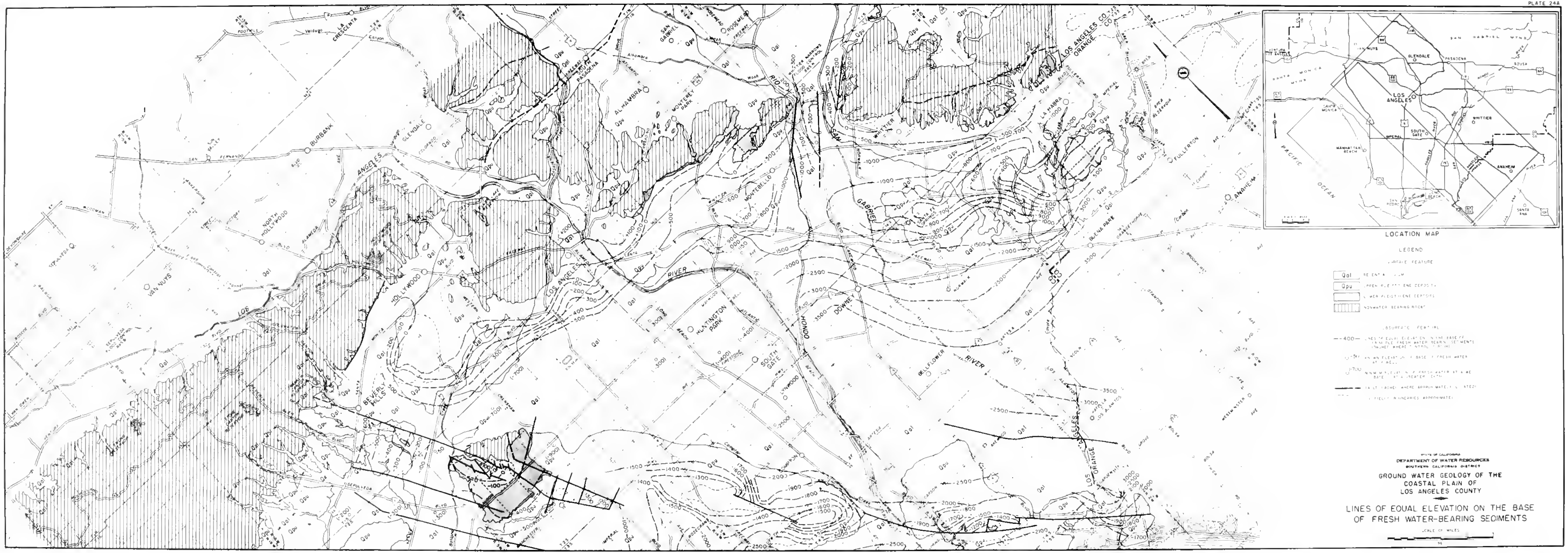
STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN CALIFORNIA DISTRICT

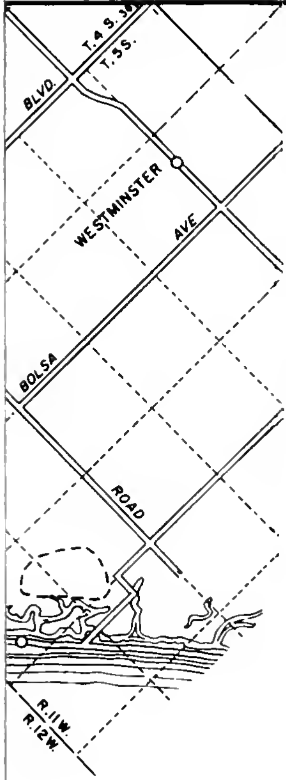
GROUND WATER GEOLOGY OF THE COASTAL PLAIN OF LOS ANGELES COUNTY

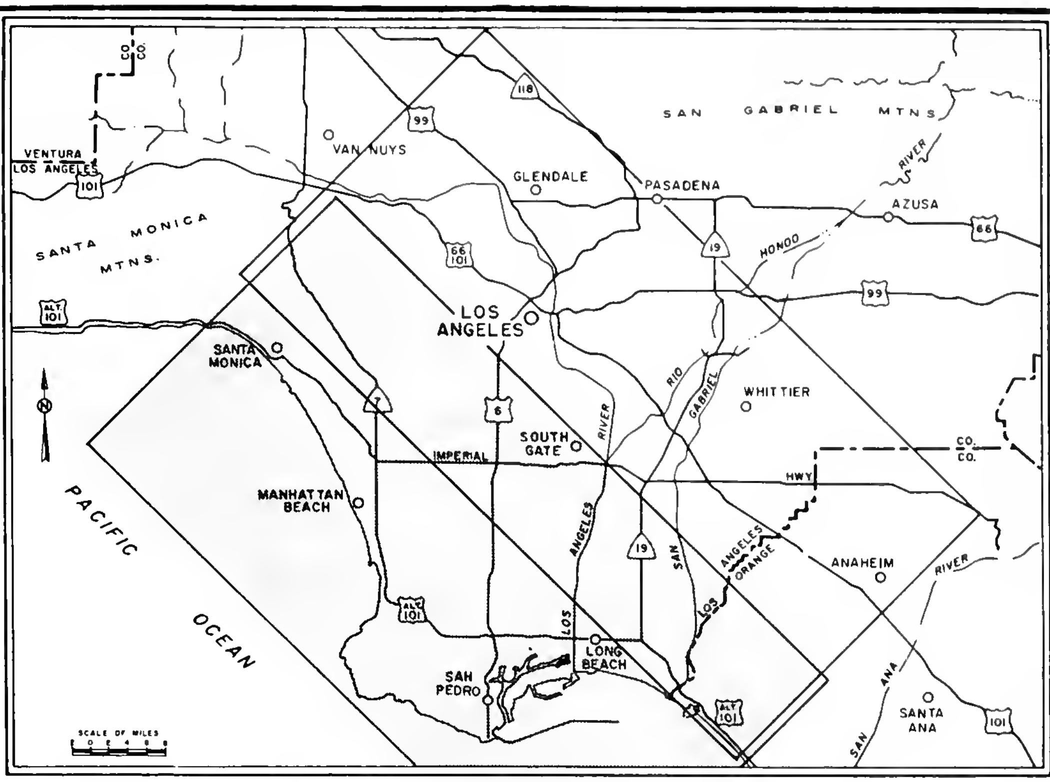
LINES OF EQUAL ELEVATION ON THE BASE OF FRESH WATER-BEARING SEDIMENTS

SCALE OF MILES
1 0 1 2 3

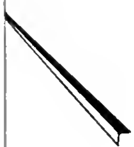
1961


LOCATION MAP
LEGEND
Qal
Qpu
—400—
STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN CALIFORNIA DISTRICT
GROUND WATER GEOLOGY OF THE
COASTAL PLAIN OF
LOS ANGELES COUNTY
LINES OF EQUAL ELEVATION ON THE BASE
OF FRESH WATER-BEARING SEDIMENTS
SCALE OF MILES
BURBANK
GLENDALE
PASADENA
ALHAMBRA
MONTEREY PARK
WHITTIER
LA HABRA
FULLERTON
ANAHEIM
NORTH HOLLYWOOD
VAN NUYS
HOLLYWOOD
LOS ANGELES
BEVERLY HILLS
HUNTINGTON PARK
SOUTH GATE
DOWNEY
BELLFLOWER
MONTEBELLO
LOS ANGELES RIVER
SAN GABRIEL RIVER
RIO HONDO
PACIFIC OCEAN





LOCATION MAP



LEGEND

SURFACE FEATURES

- Qal — RECENT ALLUVIUM
- Qpu — UPPER PLEISTOCENE DEPOSITS
- LOWER PLEISTOCENE DEPOSITS
- NONWATER-BEARING ROCKS

SUBSURFACE FEATURES

- --400— LINES OF EQUAL ELEVATION ON THE BASE OF PRINCIPLE FRESH WATER-BEARING SEDIMENTS (DASHED WHERE CONTROL IS POOR)
- O-740 KNOWN ELEVATION OF BASE OF FRESH WATER AT A WELL
- O(-700) MINIMUM ELEVATION OF FRESH WATER AT A WELL (BASE IS AT A GREATER DEPTH)
- FAULT (DASHED WHERE APPROXIMATELY LOCATED)
- OIL FIELDS (BOUNDARIES APPROXIMATE)

STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN CALIFORNIA DISTRICT

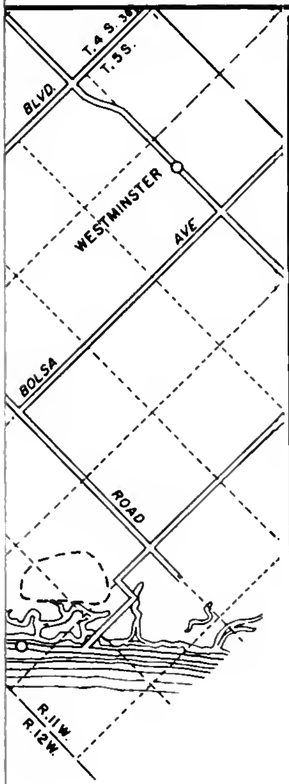
GROUND WATER GEOLOGY OF THE COASTAL PLAIN OF LOS ANGELES COUNTY

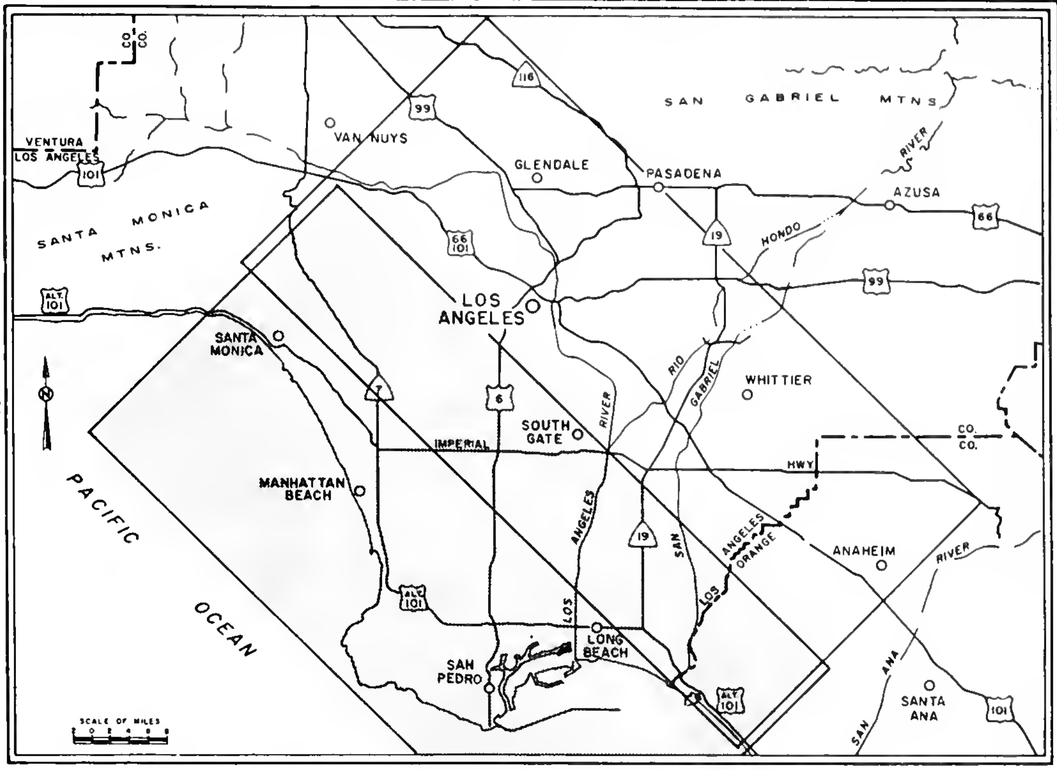
LINES OF EQUAL ELEVATION ON THE BASE OF FRESH WATER-BEARING SEDIMENTS

SCALE OF MILES

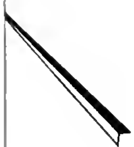
1 0 1 2 3

1961





LOCATION MAP



LEGEND

SURFACE FEATURES

Qal — RECENT ALLUVIUM

Qpu — UPPER PLEISTOCENE DEPOSITS

LOWER PLEISTOCENE DEPOSITS

NONWATER-BEARING ROCKS

SUBSURFACE FEATURES

--400— LINES OF EQUAL ELEVATION ON THE BASE OF PRINCIPLE FRESH WATER-BEARING SEDIMENTS (DASHED WHERE CONTROL IS POOR)

O-740 KNOWN ELEVATION OF BASE OF FRESH WATER AT A WELL

O(-700) MINIMUM ELEVATION OF FRESH WATER AT A WELL (BASE IS AT A GREATER DEPTH)

FAULT (DASHED WHERE APPROXIMATELY LOCATED)

OIL FIELDS (BOUNDARIES APPROXIMATE)

STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN CALIFORNIA DISTRICT

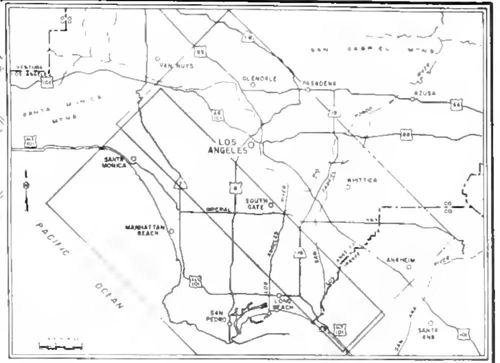
GROUND WATER GEOLOGY OF THE COASTAL PLAIN OF LOS ANGELES COUNTY

LINES OF EQUAL ELEVATION ON THE BASE OF FRESH WATER-BEARING SEDIMENTS

SCALE OF MILES

1 0 1 2 3

1961



LOCATION MAP

LEGEND

SURFACE FEATURES

Qal

Qpu

—400—

-740

(-700)

STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN CALIFORNIA DISTRICT

GROUND WATER GEOLOGY OF THE
COASTAL PLAIN OF
LOS ANGELES COUNTY

LINES OF EOUAL ELEVATION ON THE BASE
OF FRESH WATER-BEARING SEDIMENTS

SCALE OF MILES

AREA WHERE GASPUR AQUIFER IS MERGED WITH GROUND SURFACE.

AREA WHERE THE GAGE-GARDENA AQUIFER IS MERGED WITH AN OVERLYING AQUIFER.

AREAS WHERE THE HOLLYDALE AQUIFER IS MERGED WITH AN OVERLYING AQUIFER.

AREAS WHERE THE JEFFERSON AQUIFER IS MERGED WITH AN OVERLYING AQUIFER.

AREAS WHERE LYNWOOD AQUIFER IS MERGED WITH AN OVERLYING AQUIFER.

AREAS WHERE THE SILVERADO AQUIFER IS MERGED WITH AN OVERLYING AQUIFER.

AREAS WHERE THE SUNNYSIDE AQUIFER IS MERGED WITH AN OVERLYING AQUIFER.

STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN CALIFORNIA DISTRICT

GROUND WATER GEOLOGY OF THE COASTAL PLAIN OF LOS ANGELES COUNTY

AREAS WHERE AQUIFERS ARE MERGED WITH PERMEABLE SURFACE DEPOSITS OR OVERLYING AQUIFERS IN VICINITY OF WHITTIER NARROWS

SCALE OF MILES

1/2 0

1961

- AREA WHERE GASPUR AQUIFER IS MERGED WITH GROUND SURFACE.
- AREA WHERE THE GAGE-GARDENA AQUIFER IS MERGED WITH AN OVERLYING AQUIFER.
- AREAS WHERE THE HOLLYDALE AQUIFER IS MERGED WITH AN OVERLYING AQUIFER.
- AREAS WHERE THE JEFFERSON AQUIFER IS MERGED WITH AN OVERLYING AQUIFER.
- AREAS WHERE LYNWOOD AQUIFER IS MERGED WITH AN OVERLYING AQUIFER.
- AREAS WHERE THE SILVERADO AQUIFER IS MERGED WITH AN OVERLYING AQUIFER.
- AREAS WHERE THE SUNNYSIDE AQUIFER IS MERGED WITH AN OVERLYING AQUIFER.

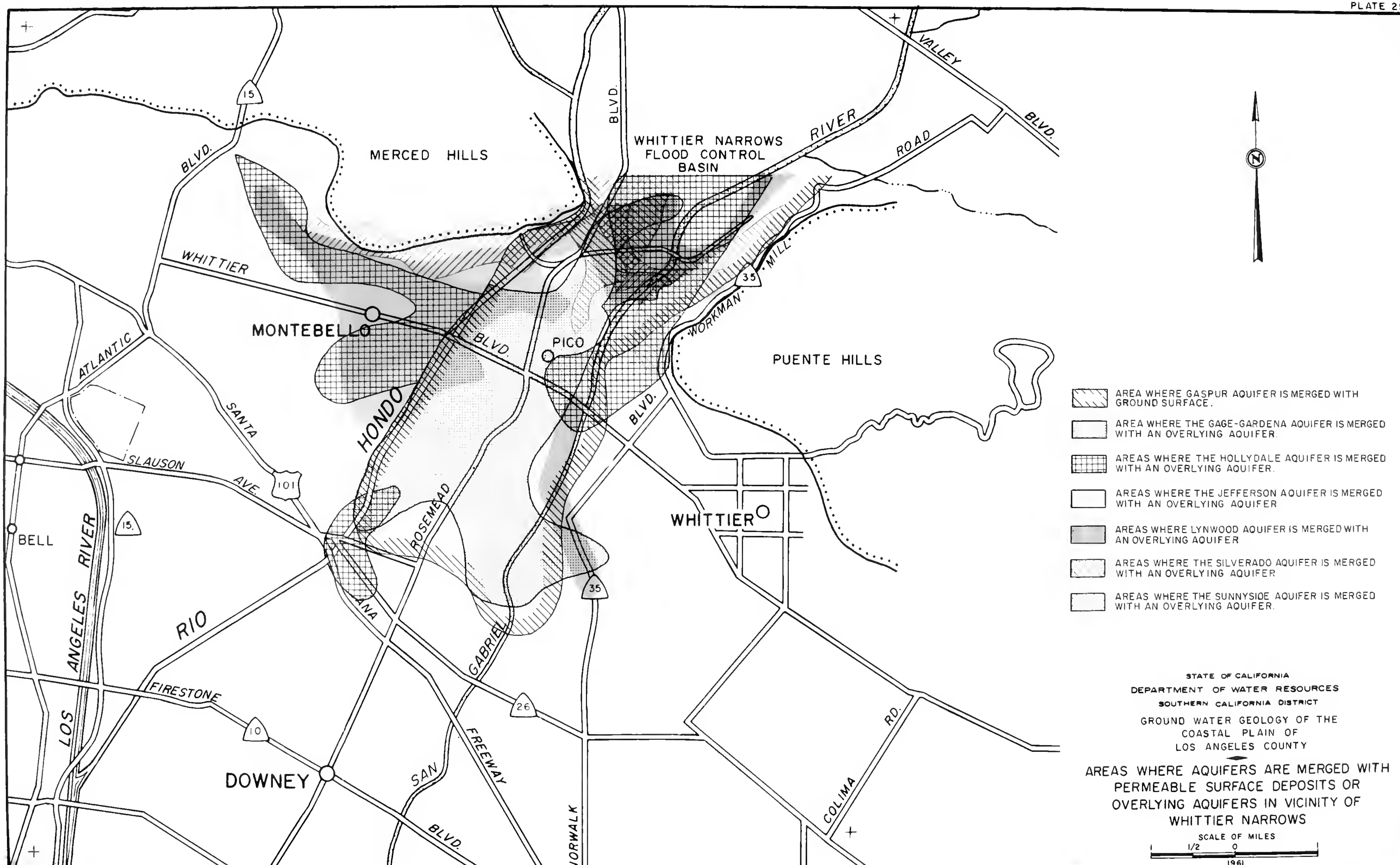
STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN CALIFORNIA DISTRICT

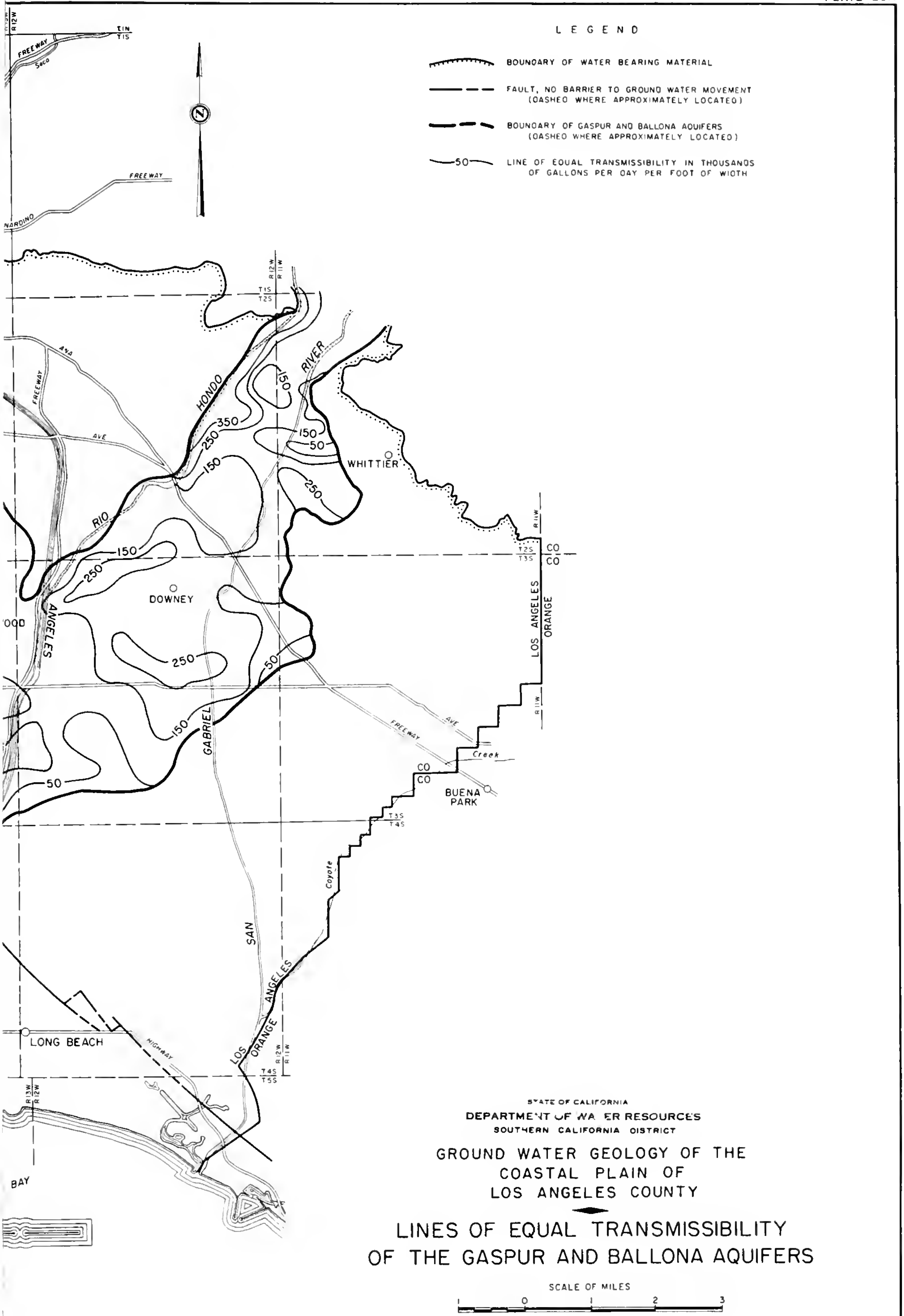
GROUND WATER GEOLOGY OF THE COASTAL PLAIN OF LOS ANGELES COUNTY

AREAS WHERE AQUIFERS ARE MERGED WITH PERMEABLE SURFACE DEPOSITS OR OVERLYING AQUIFERS IN VICINITY OF WHITTIER NARROWS

SCALE OF MILES
1/2 0

1961


MERCED HILLS
WHITTIER NARROWS
FLOOD CONTROL
BASIN
PUENTE HILLS
MONTEBELLO
PICO
WHITTIER
BELL
DOWNEY
WHITTIER BLVD.
RIO HONDO
SANTA ANA FREEWAY
SAN GABRIEL RIVER
LOS ANGELES RIVER
RIO
FIRESTONE BLVD.
SLAUSON AVE.
ATLANTIC BLVD.
ROSEMEAD BLVD.
VALLEY BLVD.
ROAD
WORKMAN MILL
NORWALK
COLIMA RD.
15
101
35
26
10
AREA WHERE GASPUR AQUIFER IS MERGED WITH GROUND SURFACE.
AREA WHERE THE GAGE-GARDENA AQUIFER IS MERGED WITH AN OVERLYING AQUIFER.
AREAS WHERE THE HOLLYDALE AQUIFER IS MERGED WITH AN OVERLYING AQUIFER.
AREAS WHERE THE JEFFERSON AQUIFER IS MERGED WITH AN OVERLYING AQUIFER
AREAS WHERE LYNWOOD AQUIFER IS MERGED WITH AN OVERLYING AQUIFER
AREAS WHERE THE SILVERADO AQUIFER IS MERGED WITH AN OVERLYING AQUIFER
AREAS WHERE THE SUNNYSIDE AQUIFER IS MERGED WITH AN OVERLYING AQUIFER.
STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN CALIFORNIA DISTRICT
GROUND WATER GEOLOGY OF THE
COASTAL PLAIN OF
LOS ANGELES COUNTY
AREAS WHERE AQUIFERS ARE MERGED WITH
PERMEABLE SURFACE DEPOSITS OR
OVERLYING AQUIFERS IN VICINITY OF
WHITTIER NARROWS
SCALE OF MILES
1/2
0
1
1961



STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN CALIFORNIA DISTRICT

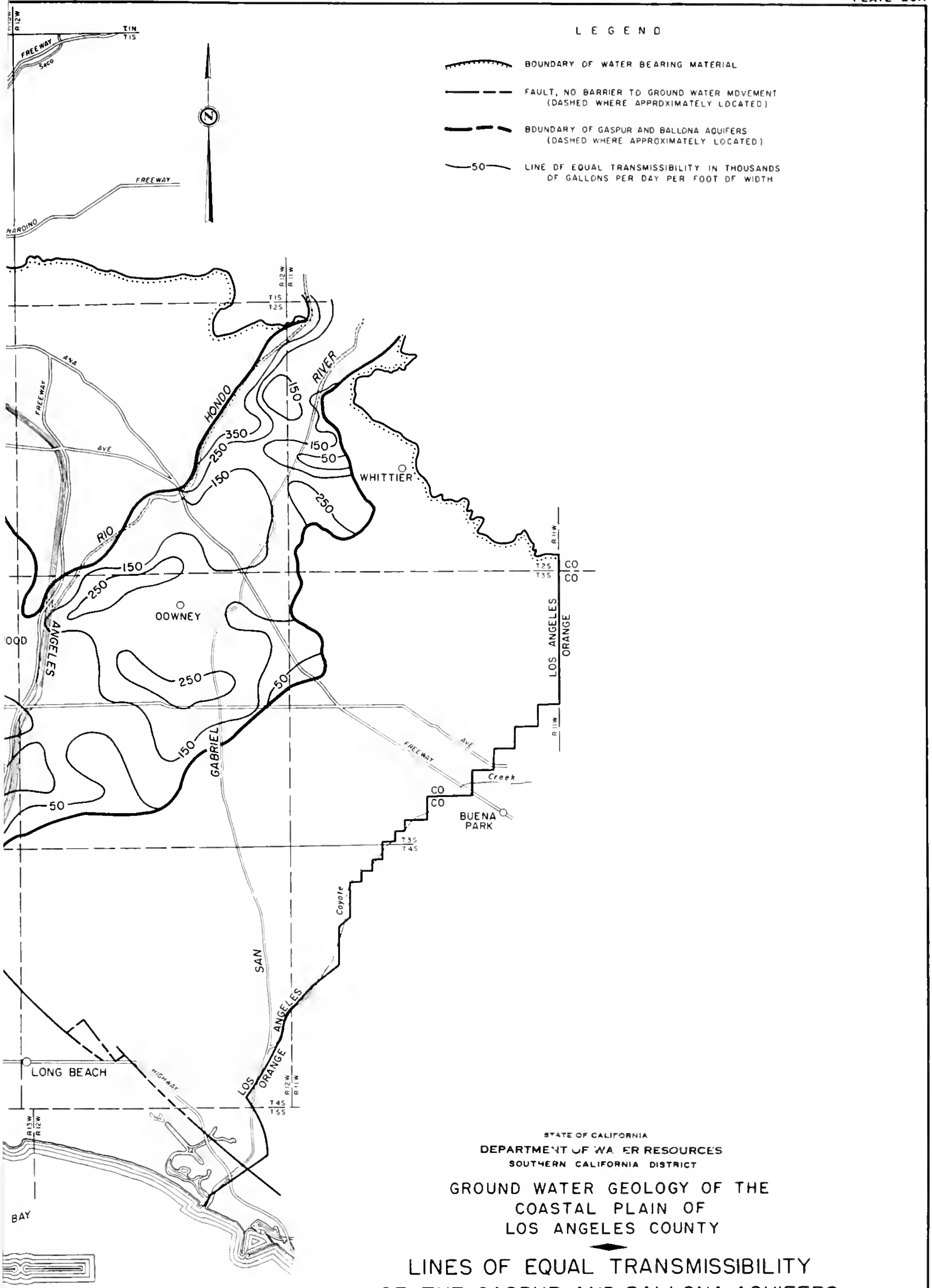
GROUND WATER GEOLOGY OF THE
COASTAL PLAIN OF
LOS ANGELES COUNTY

LINES OF EQUAL TRANSMISSIBILITY
OF THE GASPUR AND BALLONA AQUIFERS

SCALE OF MILES

1961

PLATE 26A



STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN CALIFORNIA DISTRICT

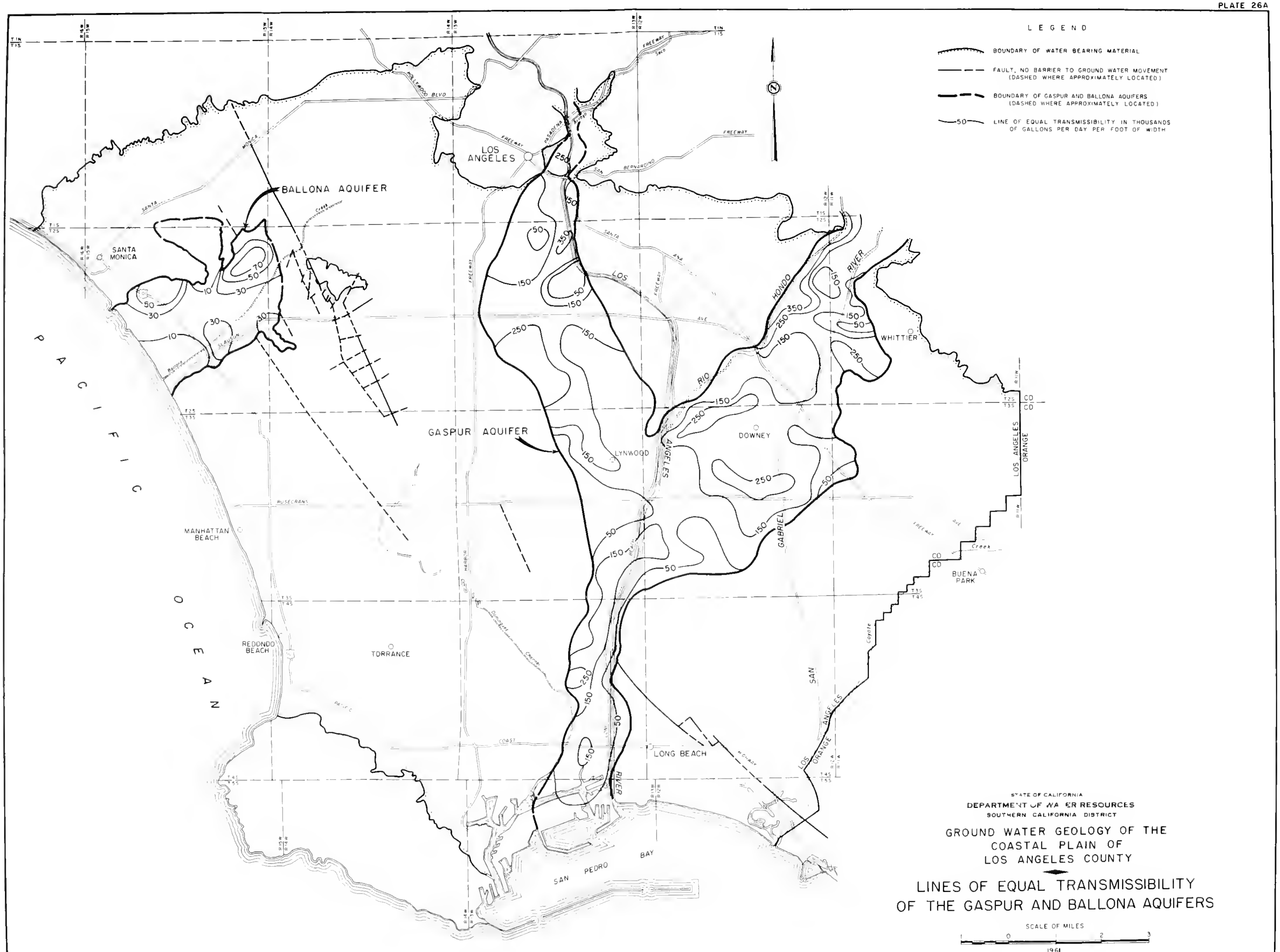
GROUND WATER GEOLOGY OF THE COASTAL PLAIN OF LOS ANGELES COUNTY

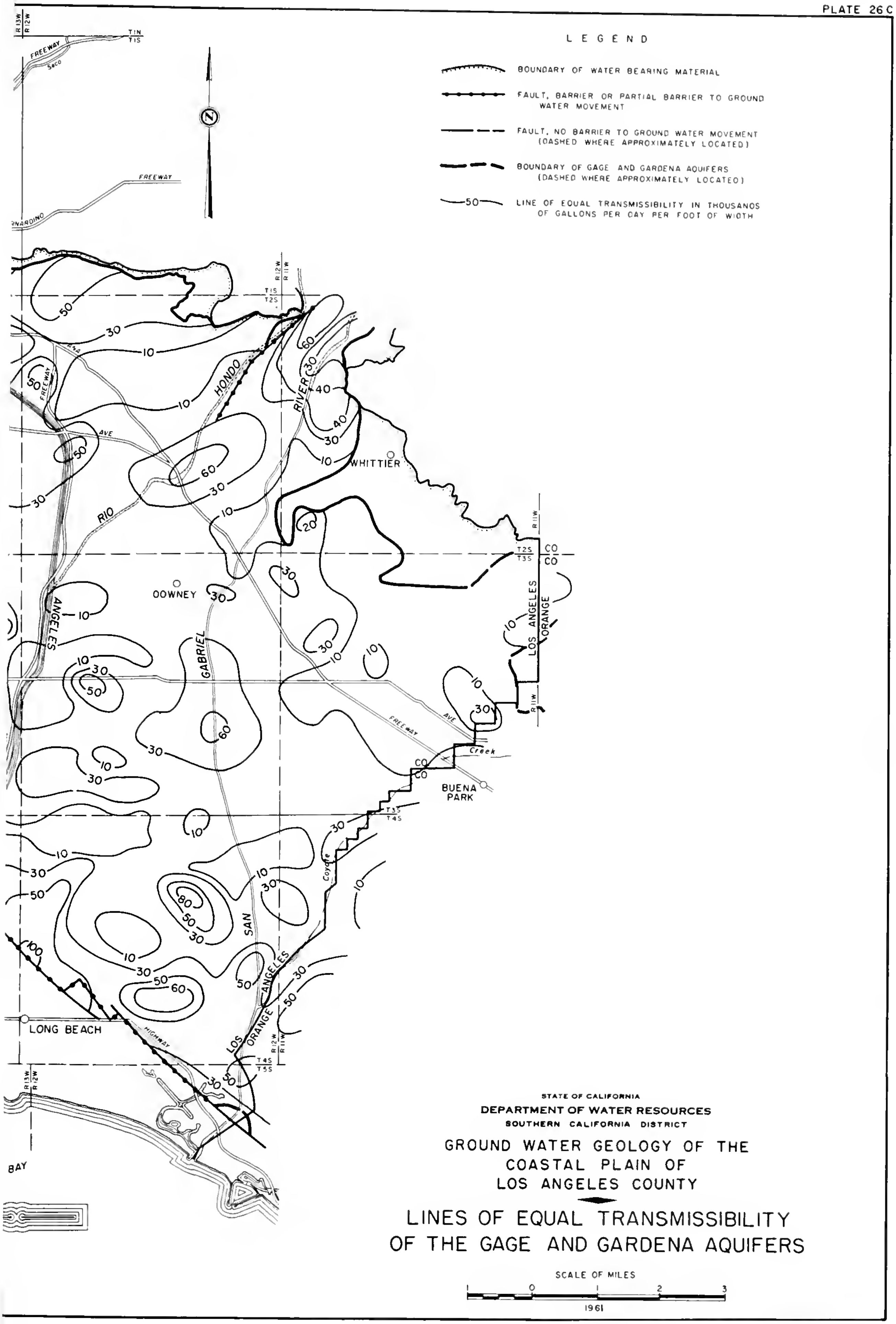
LINES OF EQUAL TRANSMISSIBILITY OF THE GASPUR AND BALLONA AQUIFERS

SCALE OF MILES
1 0 1 2 3

1961

PLATE 26A


LEGEND
BOUNDARY OF WATER BEARING MATERIAL
FAULT, NO BARRIER TO GROUND WATER MOVEMENT (DASHED WHERE APPROXIMATELY LOCATED)
BOUNDARY OF GASPUR AND BALLONA AQUIFERS (DASHED WHERE APPROXIMATELY LOCATED)
50 LINE OF EQUAL TRANSMISSIBILITY IN THOUSANDS OF GALLONS PER DAY PER FOOT OF WIDTH
N
LOS ANGELES
BALLONA AQUIFER
GASPUR AQUIFER
SANTA MONICA
MANHATTAN BEACH
REDONDO BEACH
TORRANCE
LYNWOOD
DOWNEY
WHITTIER
BUENA PARK
LONG BEACH
PACIFIC OCEAN
SAN PEDRO BAY
HOLLYWOOD BLVD
FREEWAY
PASADENA
SAN BERNARDINO
SANTA MONICA
SLAUSON
ROSECRANS
LOS ANGELES RIVER
RIO HONDO
SAN GABRIEL RIVER
LOS ANGELES
ORANGE
CO
Coyote Creek
STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN CALIFORNIA DISTRICT
GROUND WATER GEOLOGY OF THE COASTAL PLAIN OF LOS ANGELES COUNTY
LINES OF EQUAL TRANSMISSIBILITY OF THE GASPUR AND BALLONA AQUIFERS
SCALE OF MILES
1 0 1 2 3
1961



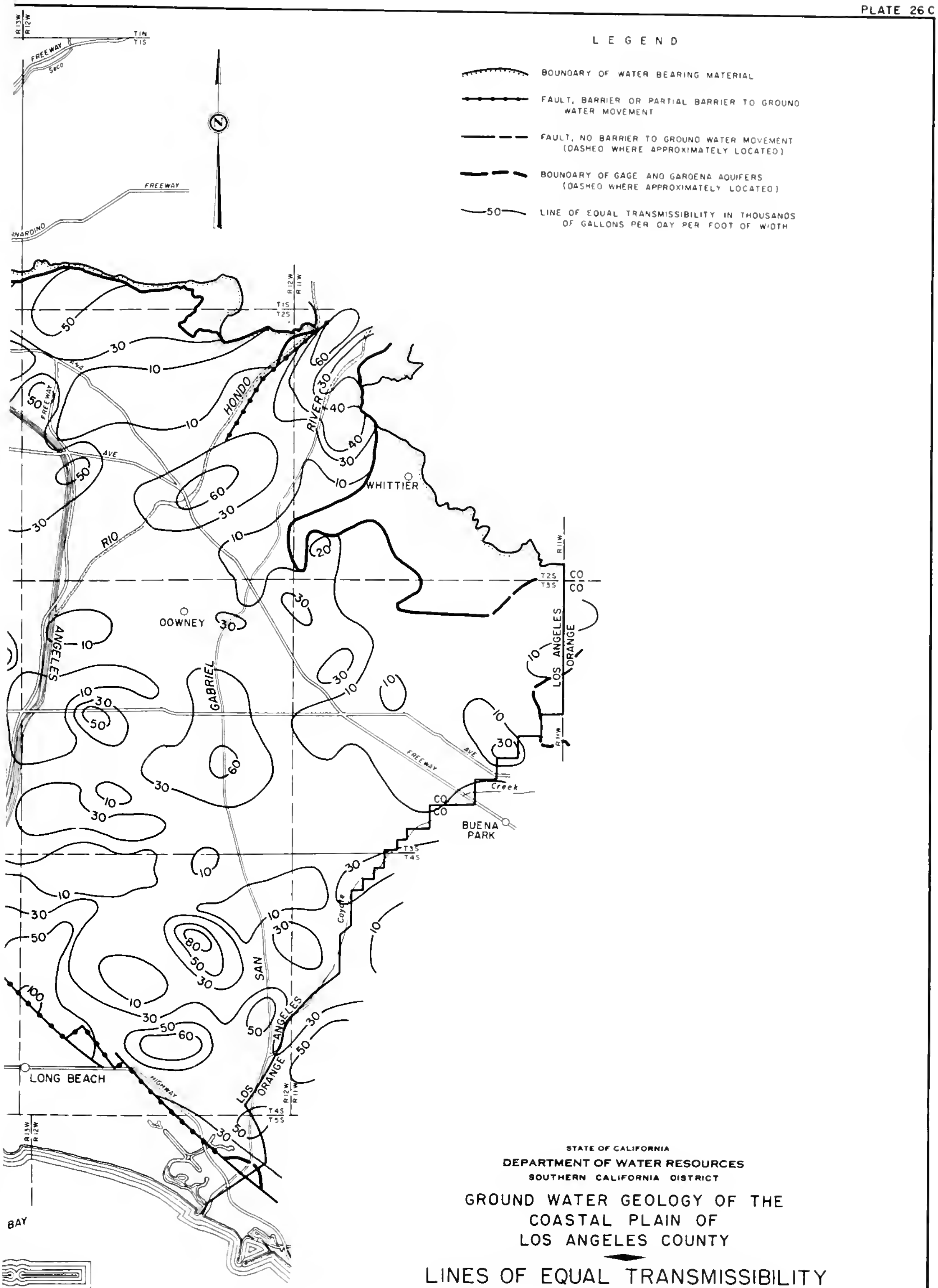
STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN CALIFORNIA DISTRICT

GROUND WATER GEOLOGY OF THE COASTAL PLAIN OF LOS ANGELES COUNTY

LINES OF EQUAL TRANSMISSIBILITY OF THE GAGE AND GARDENA AQUIFERS

SCALE OF MILES

1961



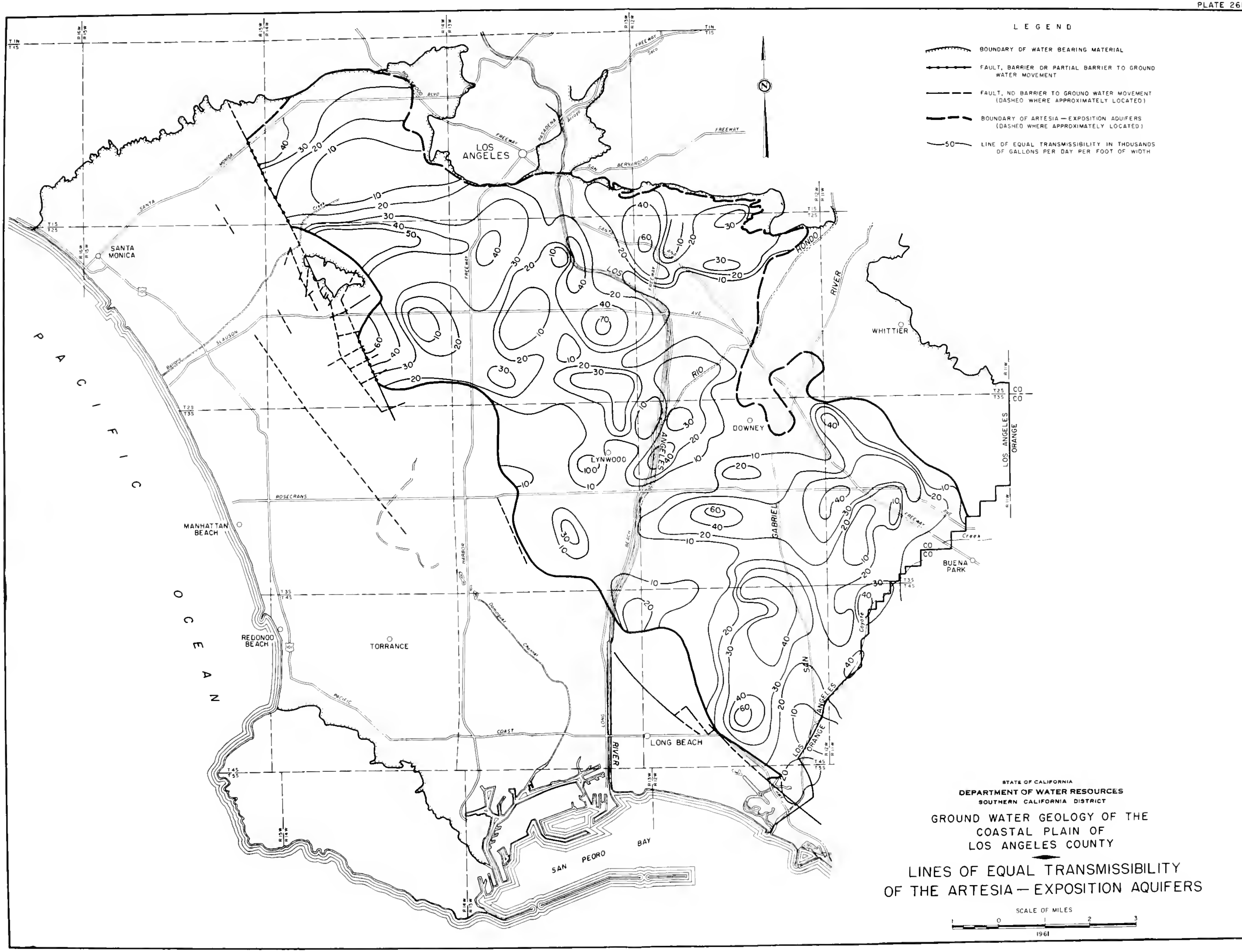
STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN CALIFORNIA DISTRICT

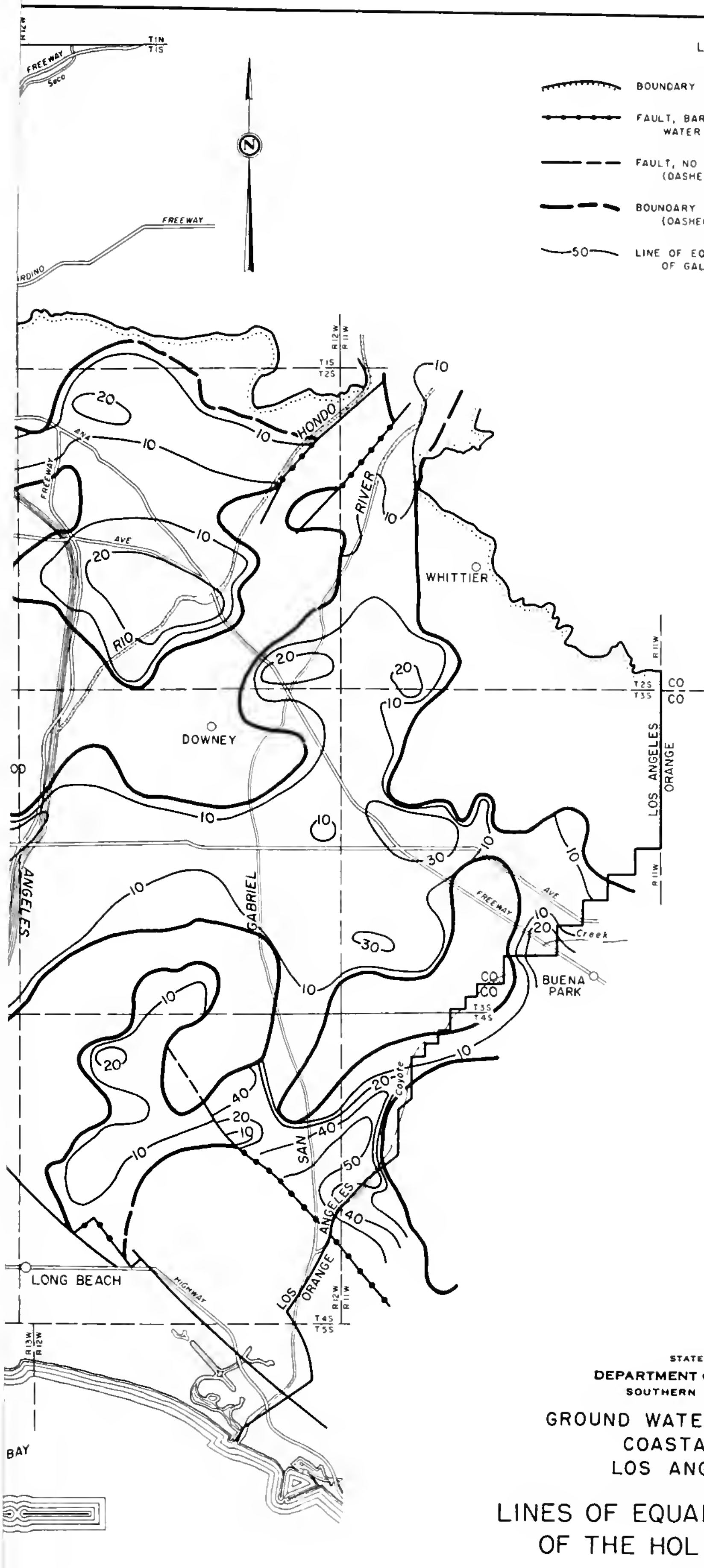
GROUND WATER GEOLOGY OF THE COASTAL PLAIN OF LOS ANGELES COUNTY

LINES OF EQUAL TRANSMISSIBILITY OF THE GAGE AND GARDENA AQUIFERS

SCALE OF MILES
1 0 1 2 3

1961


LEGEND
BOUNDARY OF WATER BEARING MATERIAL
FAULT, BARRIER OR PARTIAL BARRIER TO GROUND WATER MOVEMENT
FAULT, NO BARRIER TO GROUND WATER MOVEMENT (DASHED WHERE APPROXIMATELY LOCATED)
BOUNDARY OF ARTESIA — EXPOSITION AQUIFERS (DASHED WHERE APPROXIMATELY LOCATED)
—50— LINE OF EQUAL TRANSMISSIBILITY IN THOUSANDS OF GALLONS PER DAY PER FOOT OF WIDTH
STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN CALIFORNIA DISTRICT
GROUND WATER GEOLOGY OF THE COASTAL PLAIN OF LOS ANGELES COUNTY
LINES OF EQUAL TRANSMISSIBILITY OF THE ARTESIA — EXPOSITION AQUIFERS
SCALE OF MILES
1 0 1 2 3
1961
LOS ANGELES
SANTA MONICA
WHITTIER
DOWNEY
LYNWOOD
MANHATTAN BEACH
REDONDO BEACH
TORRANCE
LONG BEACH
BUENA PARK
PACIFIC OCEAN
SAN PEDRO BAY
LOS ANGELES RIVER
SAN GABRIEL RIVER
RIO HONDO
LOS ANGELES
ORANGE



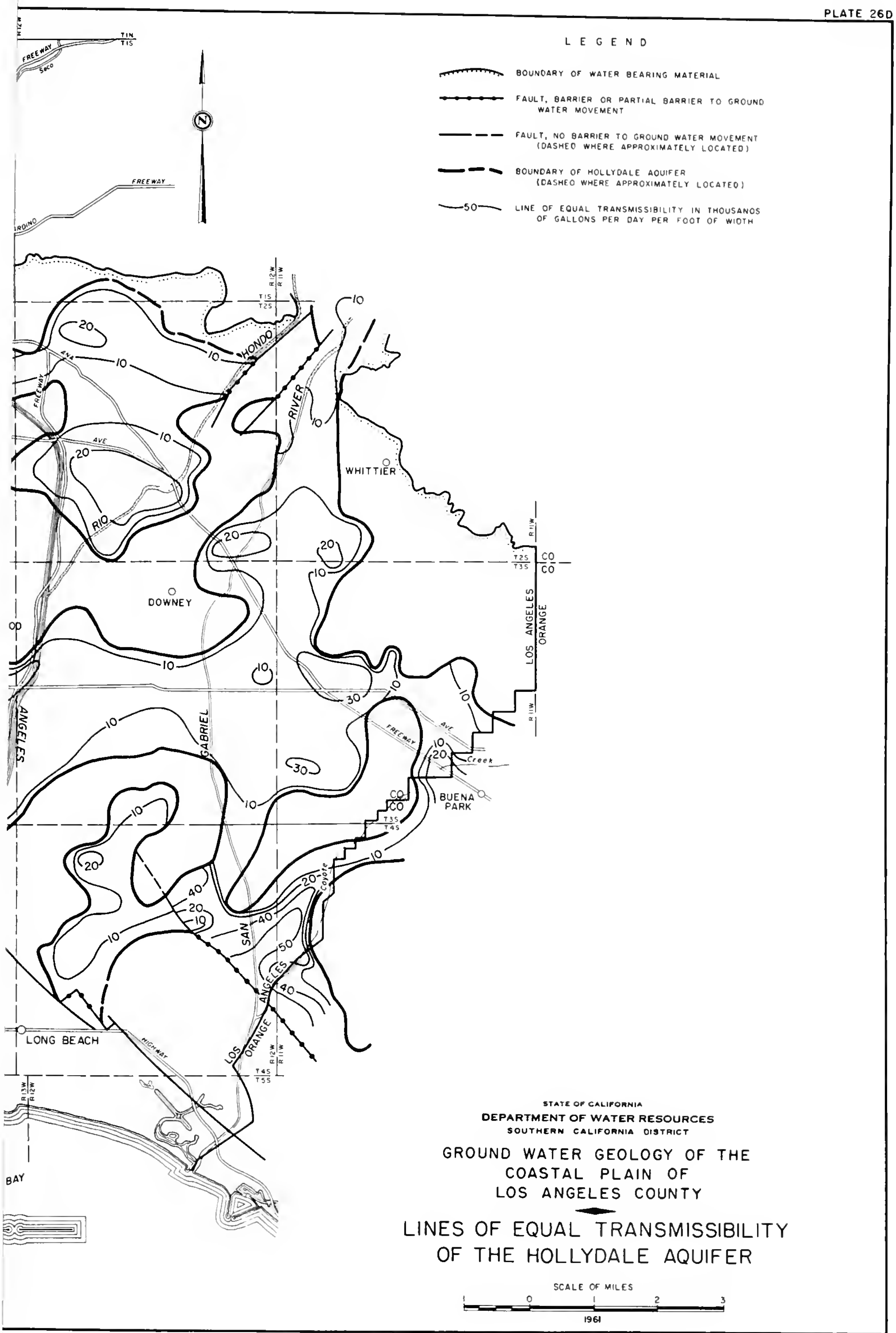
STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN CALIFORNIA DISTRICT

GROUND WATER GEOLOGY OF THE
COASTAL PLAIN OF
LOS ANGELES COUNTY

LINES OF EQUAL TRANSMISSIBILITY OF THE HOLLYDALE AQUIFER

SCALE OF MILES
1 0 1 2 3

1961



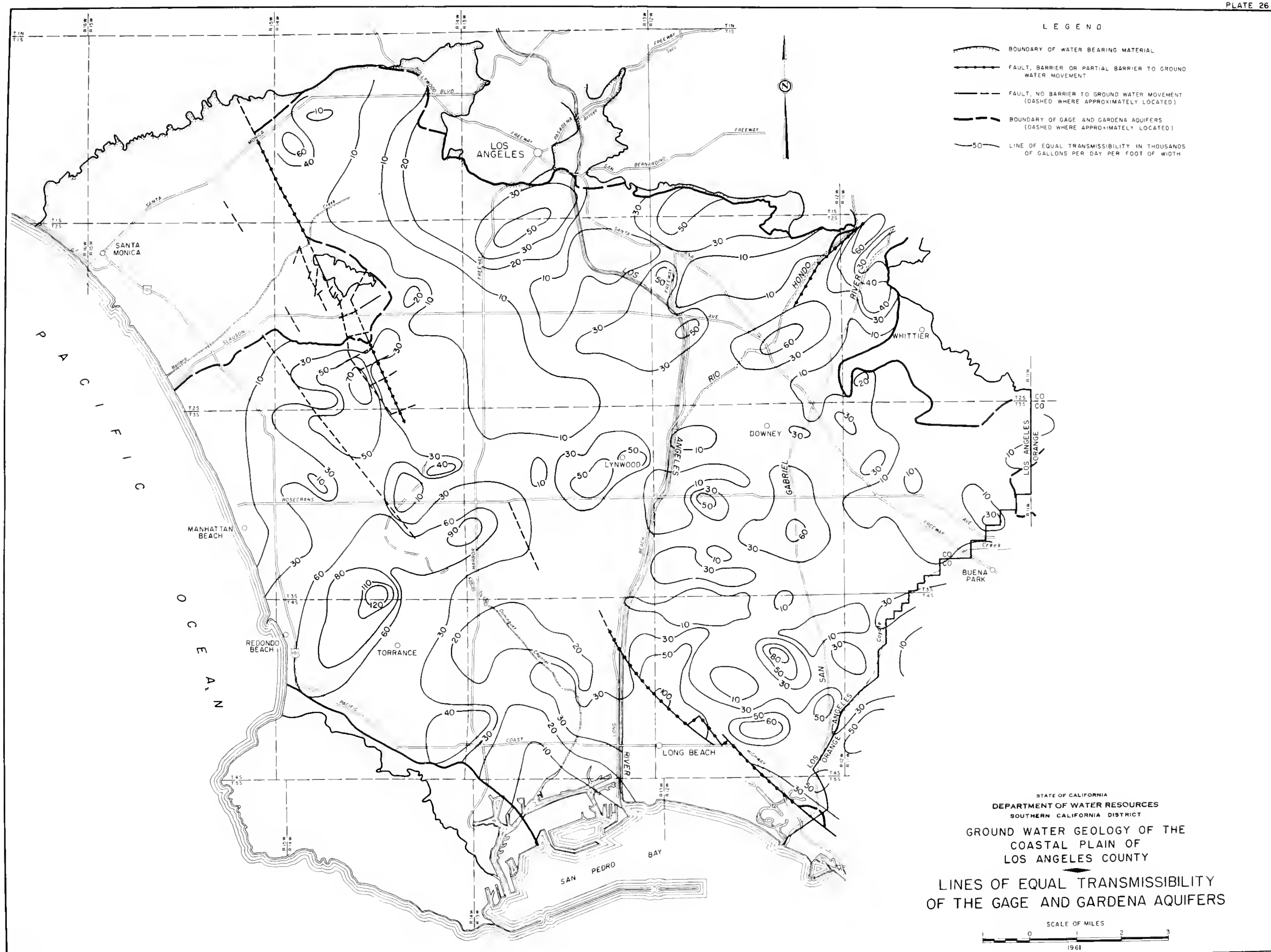
STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN CALIFORNIA DISTRICT

GROUND WATER GEOLOGY OF THE
COASTAL PLAIN OF
LOS ANGELES COUNTY

LINES OF EQUAL TRANSMISSIBILITY OF THE HOLLYDALE AQUIFER

SCALE OF MILES
1 0 1 2 3

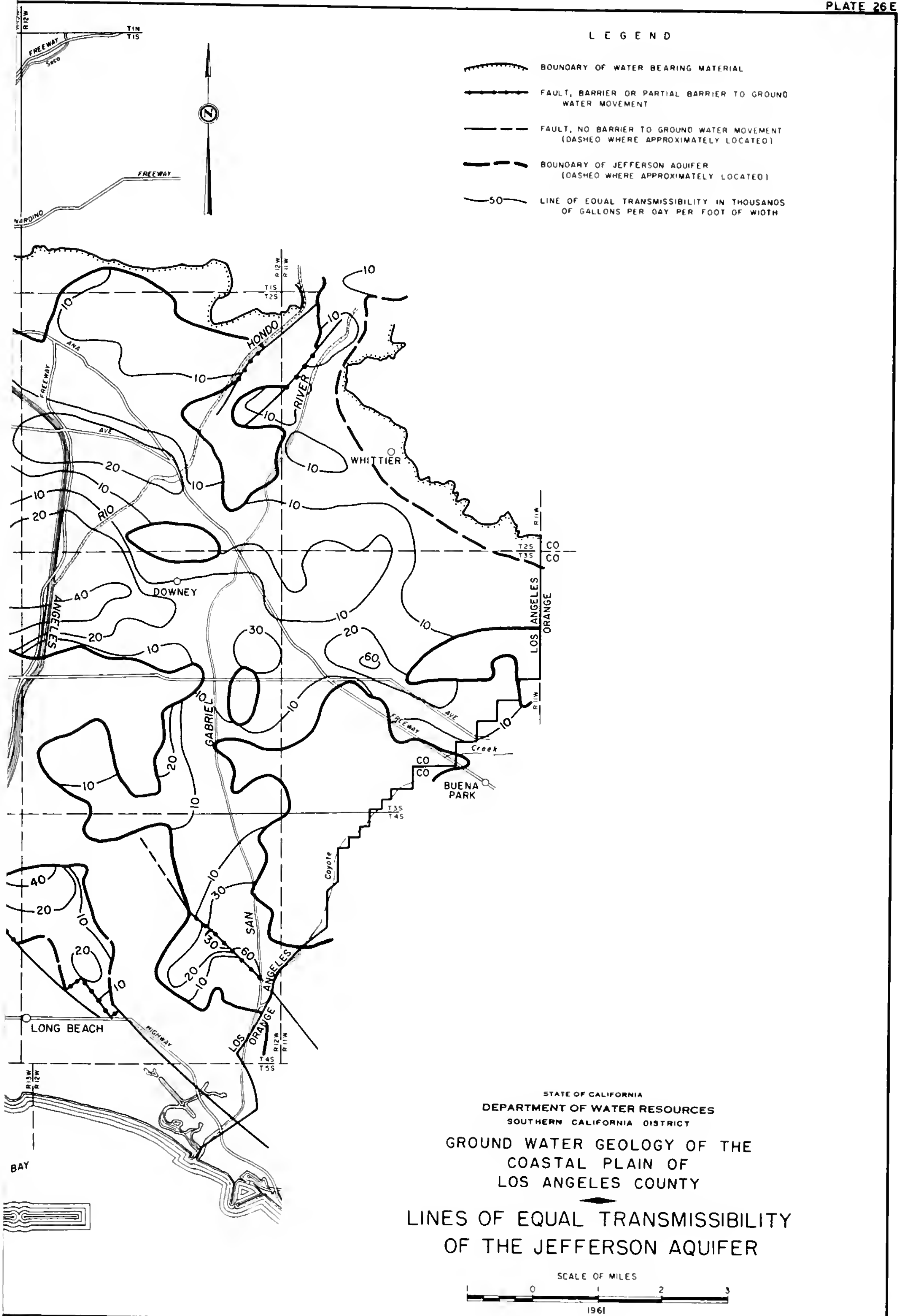
1961



STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN CALIFORNIA DISTRICT

GROUND WATER GEOLOGY OF THE COASTAL PLAIN OF LOS ANGELES COUNTY

LINES OF EQUAL TRANSMISSIBILITY OF THE GAGE AND GARDENA AQUIFERS



STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN CALIFORNIA DISTRICT

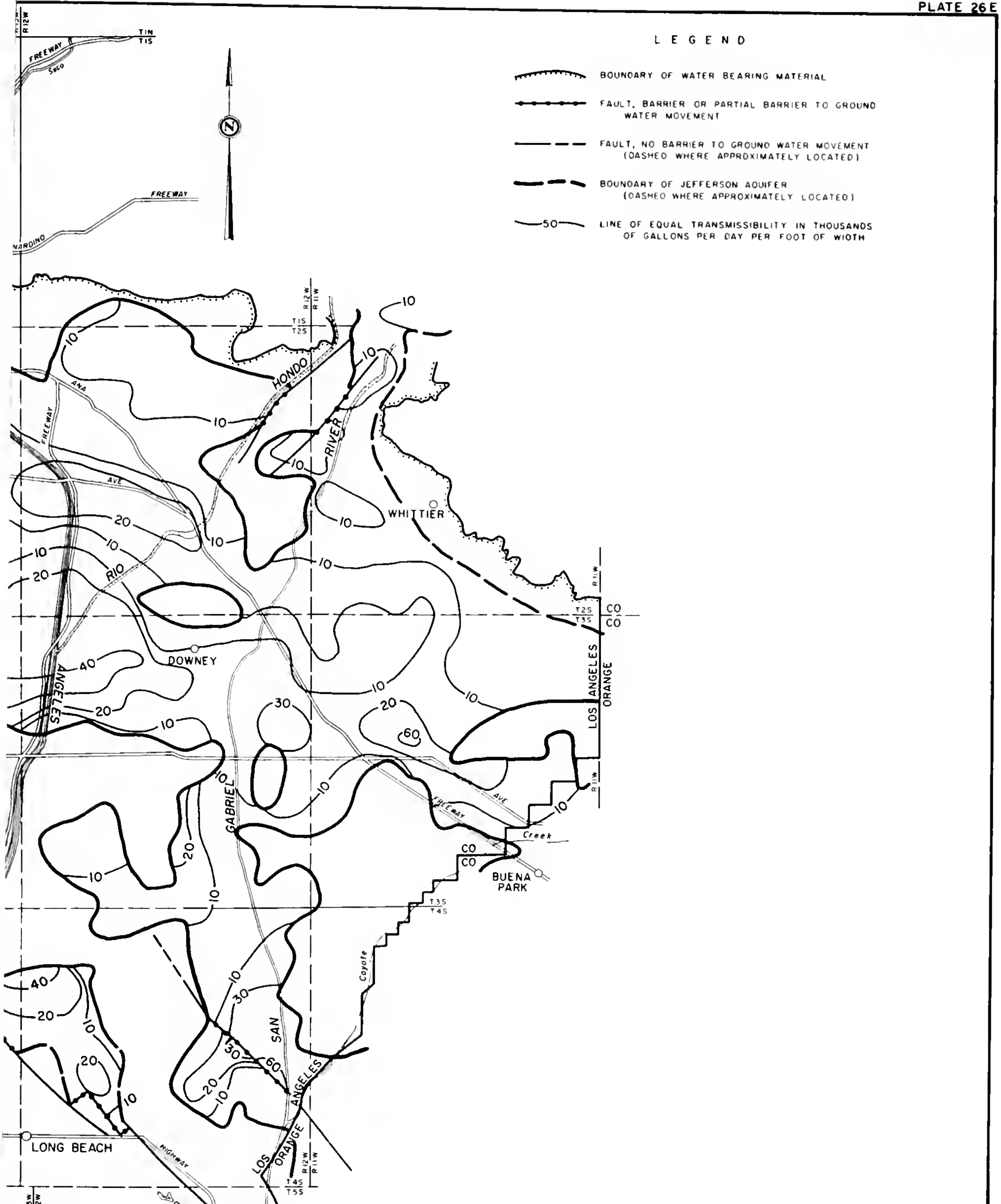
GROUND WATER GEOLOGY OF THE COASTAL PLAIN OF LOS ANGELES COUNTY

LINES OF EQUAL TRANSMISSIBILITY OF THE JEFFERSON AQUIFER

SCALE OF MILES

1961

PLATE 26 E



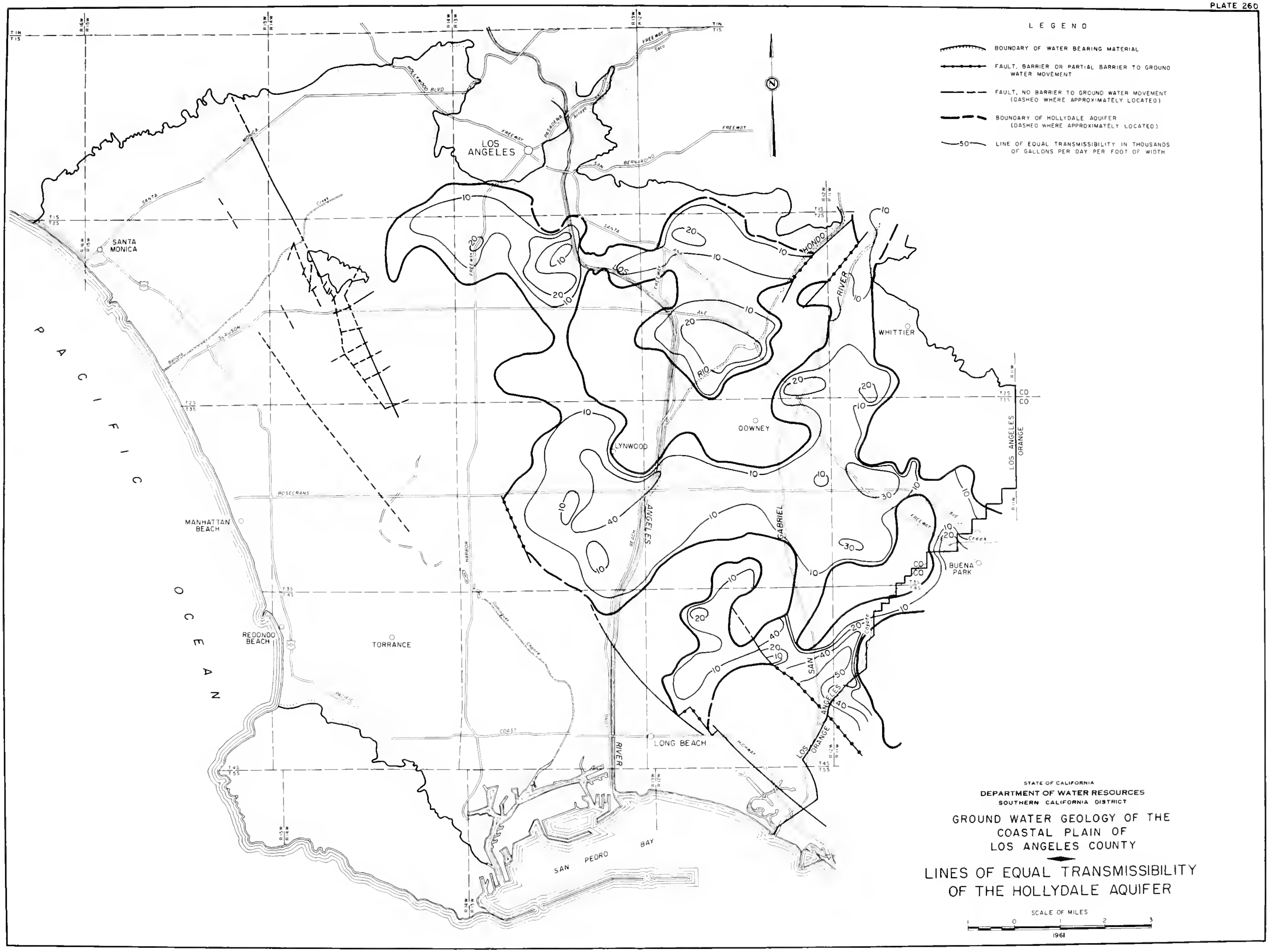
STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN CALIFORNIA DISTRICT

GROUND WATER GEOLOGY OF THE COASTAL PLAIN OF LOS ANGELES COUNTY

LINES OF EQUAL TRANSMISSIBILITY OF THE JEFFERSON AQUIFER

SCALE OF MILES
1 0 1 2 3

1961

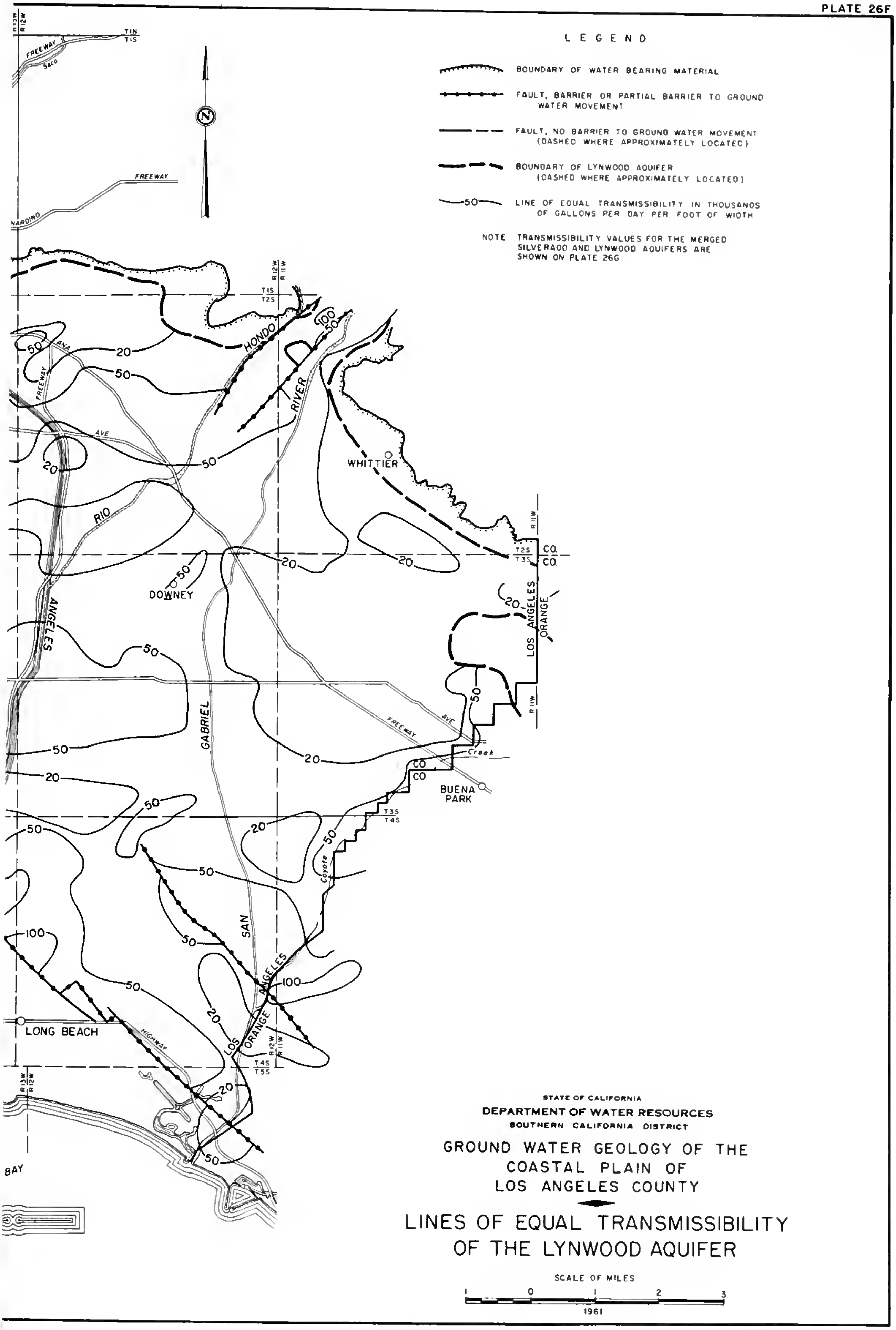


STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN CALIFORNIA DISTRICT

GROUND WATER GEOLOGY OF THE COASTAL PLAIN OF LOS ANGELES COUNTY

LINES OF EQUAL TRANSMISSIBILITY OF THE HOLLYDALE AQUIFER

1961



LEGEND

BOUNDARY OF WATER BEARING MATERIAL

FAULT, BARRIER OR PARTIAL BARRIER TO GROUND WATER MOVEMENT

FAULT, NO BARRIER TO GROUND WATER MOVEMENT (DASHED WHERE APPROXIMATELY LOCATED)

BOUNDARY OF LYNWOOD AQUIFER (DASHED WHERE APPROXIMATELY LOCATED)

—50— LINE OF EQUAL TRANSMISSIBILITY IN THOUSANDS OF GALLONS PER DAY PER FOOT OF WIDTH

NOTE TRANSMISSIBILITY VALUES FOR THE MERGED SILVERADO AND LYNWOOD AQUIFERS ARE SHOWN ON PLATE 26G

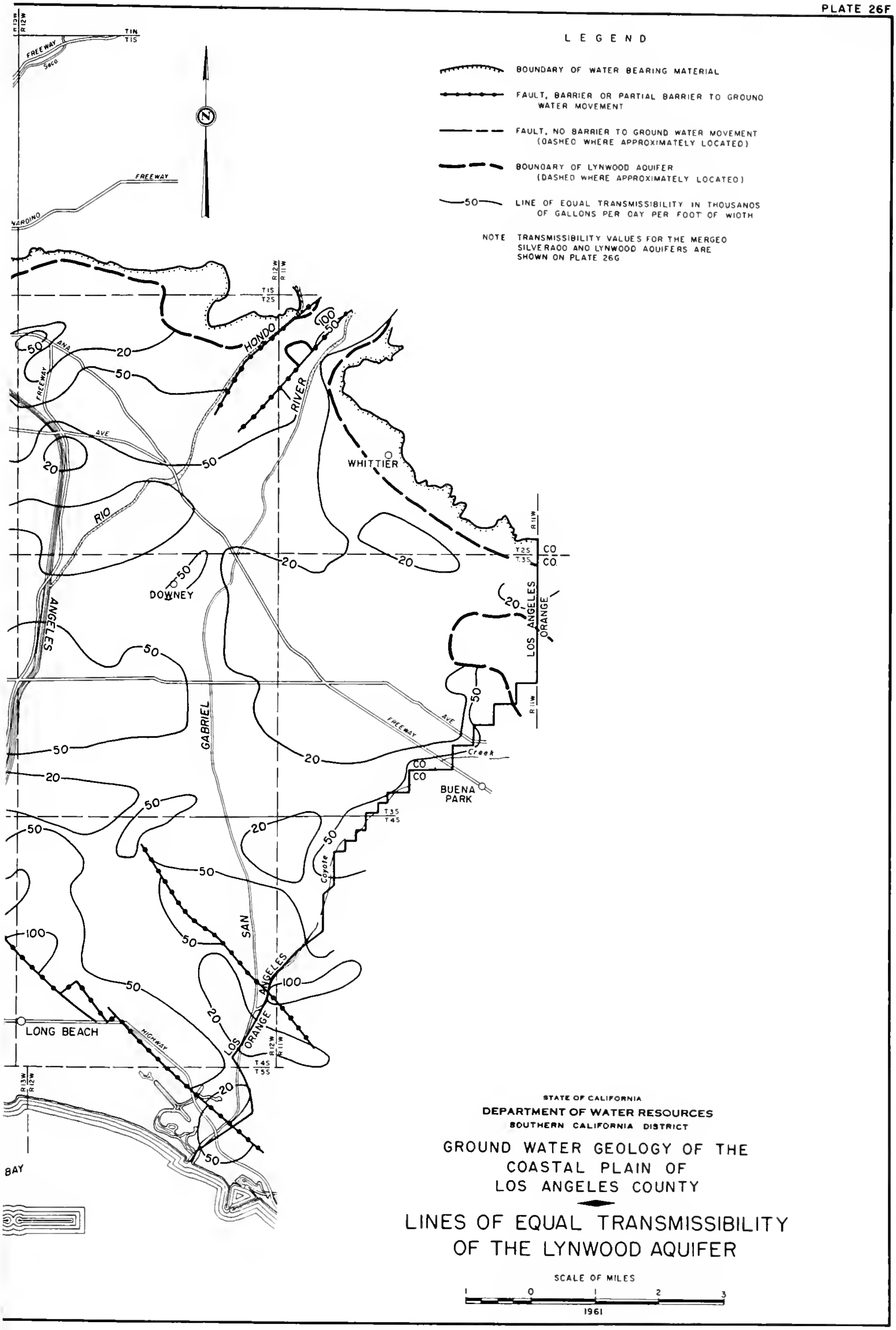
STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN CALIFORNIA DISTRICT

GROUND WATER GEOLOGY OF THE COASTAL PLAIN OF LOS ANGELES COUNTY

LINES OF EQUAL TRANSMISSIBILITY OF THE LYNWOOD AQUIFER

SCALE OF MILES
1 0 1 2 3

1961



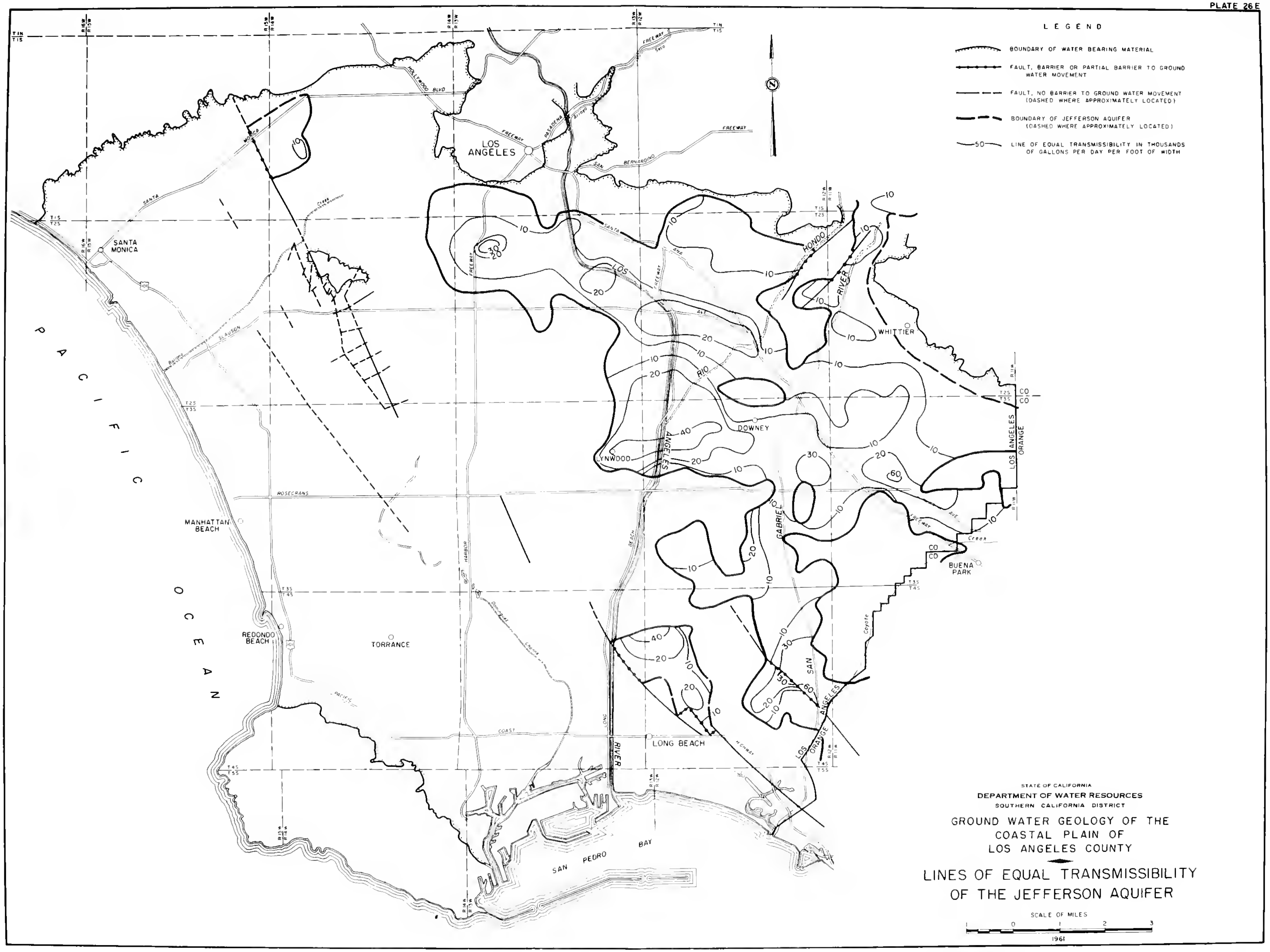
STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN CALIFORNIA DISTRICT

GROUND WATER GEOLOGY OF THE
COASTAL PLAIN OF
LOS ANGELES COUNTY

LINES OF EQUAL TRANSMISSIBILITY
OF THE LYNWOOD AQUIFER

SCALE OF MILES
1 0 1 2 3

1961



STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN CALIFORNIA DISTRICT

GROUND WATER GEOLOGY OF THE COASTAL PLAIN OF LOS ANGELES COUNTY

LINES OF EQUAL TRANSMISSIBILITY OF THE JEFFERSON AQUIFER

SCALE OF MILES

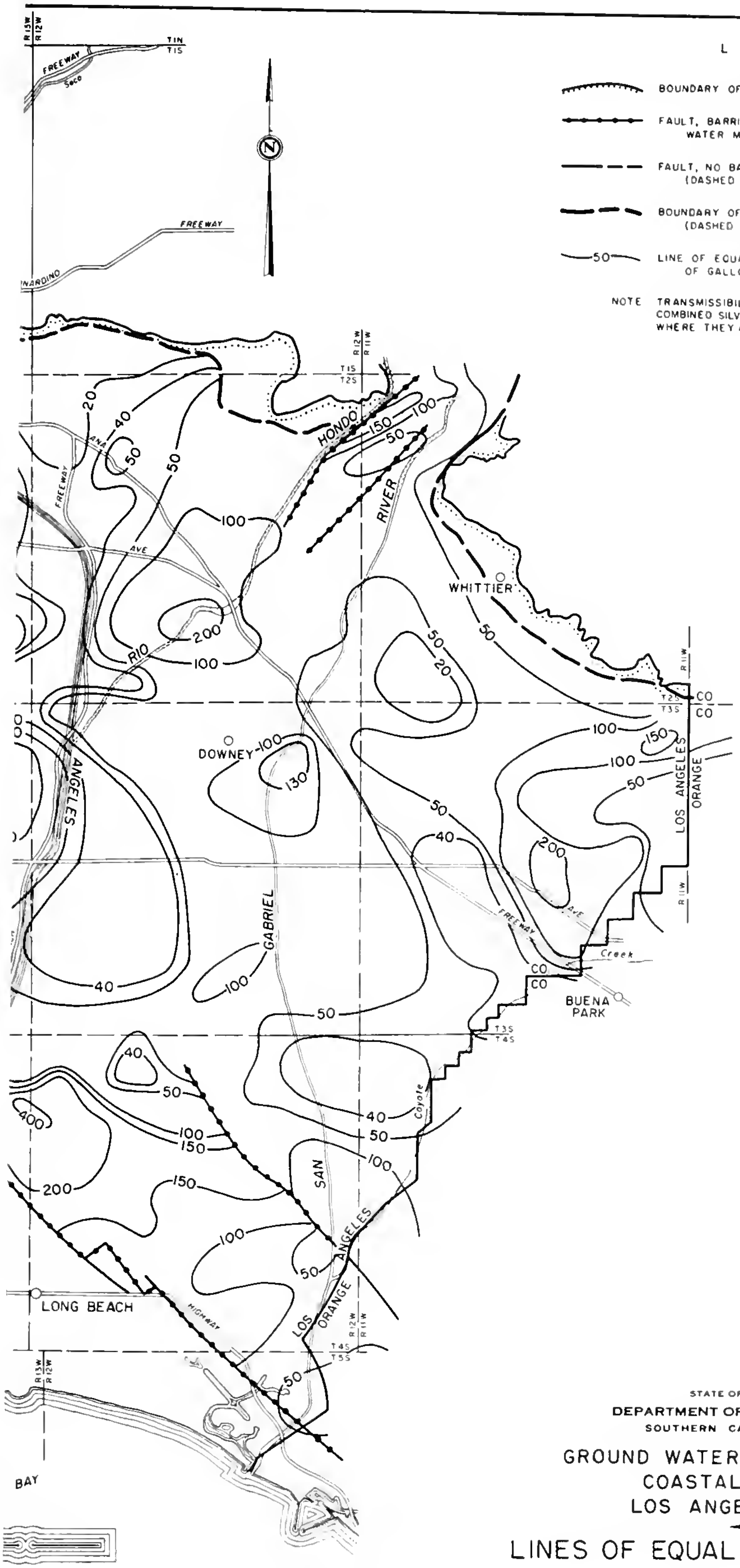
1 0 1 2 3

1961

LEGEND

- BOUNDARY OF WATER BEARING MATERIAL
- FAULT, BARRIER OR PARTIAL BARRIER TO GROUND WATER MOVEMENT
- FAULT, NO BARRIER TO GROUND WATER MOVEMENT (DASHED WHERE APPROXIMATELY LOCATED)
- BOUNDARY OF SILVERADO AQUIFER (DASHED WHERE APPROXIMATELY LOCATED)
- 50 LINE OF EQUAL TRANSMISSIBILITY IN THOUSANDS OF GALLONS PER DAY PER FOOT OF WIDTH

NOTE TRANSMISSIBILITY VALUES REPRESENT THE COMBINED SILVERADO AND LYNWOOD AQUIFERS WHERE THEY ARE MERGED



STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN CALIFORNIA DISTRICT

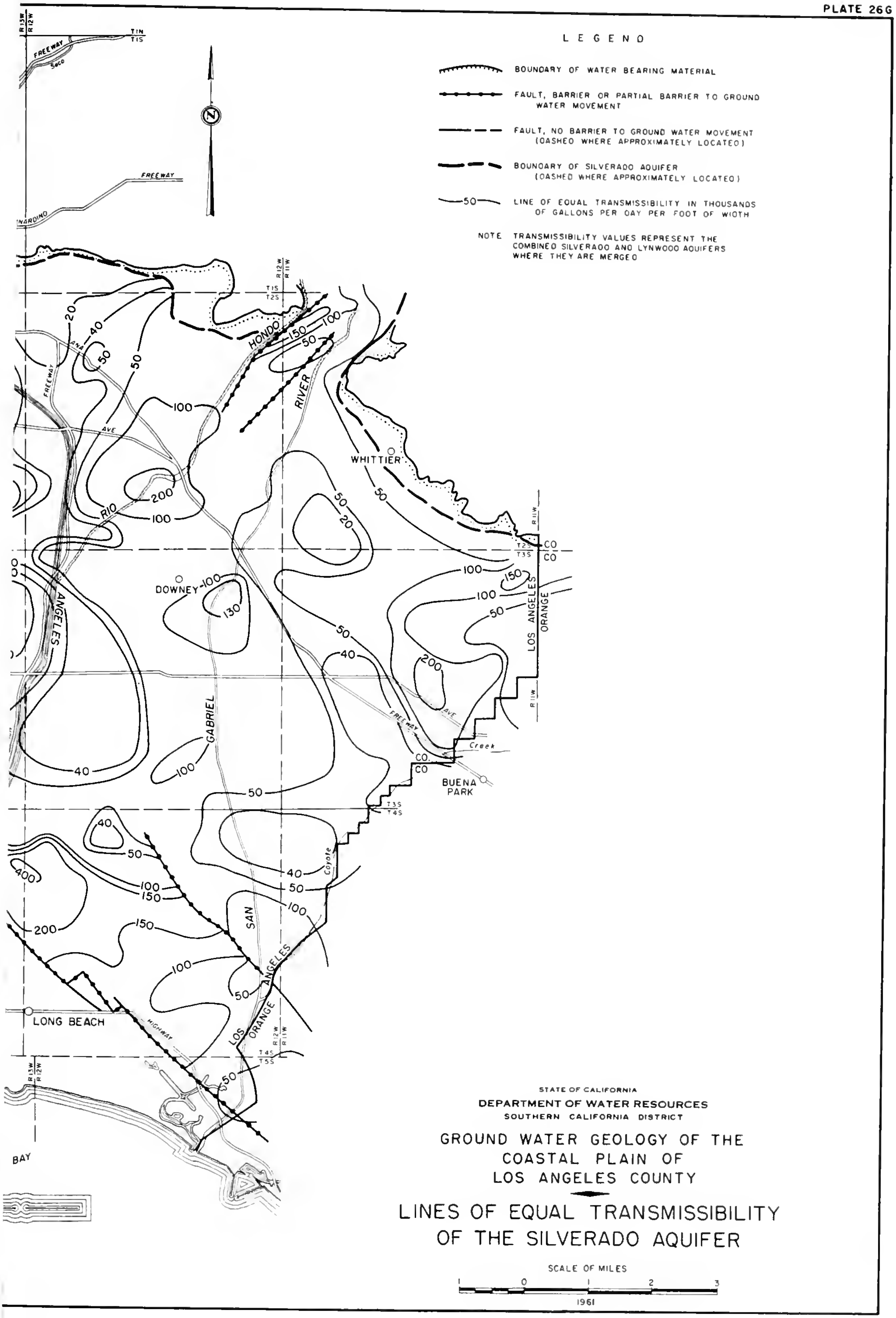
GROUND WATER GEOLOGY OF THE COASTAL PLAIN OF LOS ANGELES COUNTY

LINES OF EQUAL TRANSMISSIBILITY OF THE SILVERADO AQUIFER

SCALE OF MILES

1 0 1 2 3

1961



STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN CALIFORNIA DISTRICT

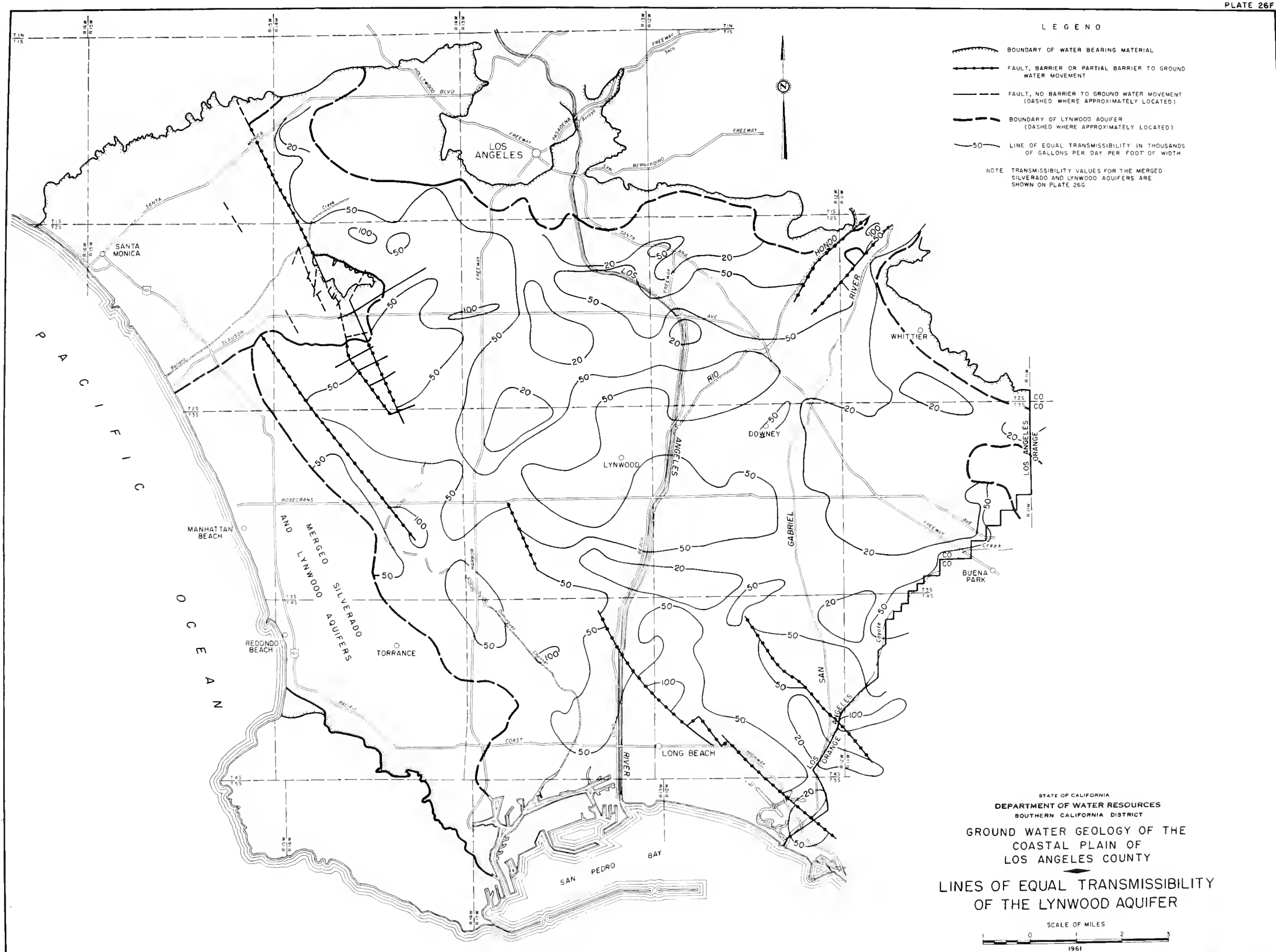
GROUND WATER GEOLOGY OF THE COASTAL PLAIN OF LOS ANGELES COUNTY

LINES OF EQUAL TRANSMISSIBILITY OF THE SILVERADO AQUIFER

SCALE OF MILES
1 0 1 2 3

1961

PLATE 26F


LEGEND
BOUNDARY OF WATER BEARING MATERIAL
FAULT, BARRIER OR PARTIAL BARRIER TO GROUND WATER MOVEMENT
FAULT, NO BARRIER TO GROUND WATER MOVEMENT (DASHED WHERE APPROXIMATELY LOCATED)
BOUNDARY OF LYNWOOD AQUIFER (DASHED WHERE APPROXIMATELY LOCATED)
50 LINE OF EQUAL TRANSMISSIBILITY IN THOUSANDS OF GALLONS PER DAY PER FOOT OF WIDTH
NOTE TRANSMISSIBILITY VALUES FOR THE MERGED SILVERADO AND LYNWOOD AQUIFERS ARE SHOWN ON PLATE 26G
PACIFIC OCEAN
MERGED SILVERADO AND LYNWOOD AQUIFERS
LOS ANGELES
SANTA MONICA
MANHATTAN BEACH
REDONDO BEACH
TORRANCE
LYNWOOD
DOWNEY
WHITTIER
BUENA PARK
LONG BEACH
SAN PEDRO BAY
LOS ANGELES RIVER
RIO HONDO
SAN GABRIEL RIVER
LOS ANGELES CO
ORANGE CO
STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN CALIFORNIA DISTRICT
GROUND WATER GEOLOGY OF THE COASTAL PLAIN OF LOS ANGELES COUNTY
LINES OF EQUAL TRANSMISSIBILITY OF THE LYNWOOD AQUIFER
SCALE OF MILES
1961

LEGEND

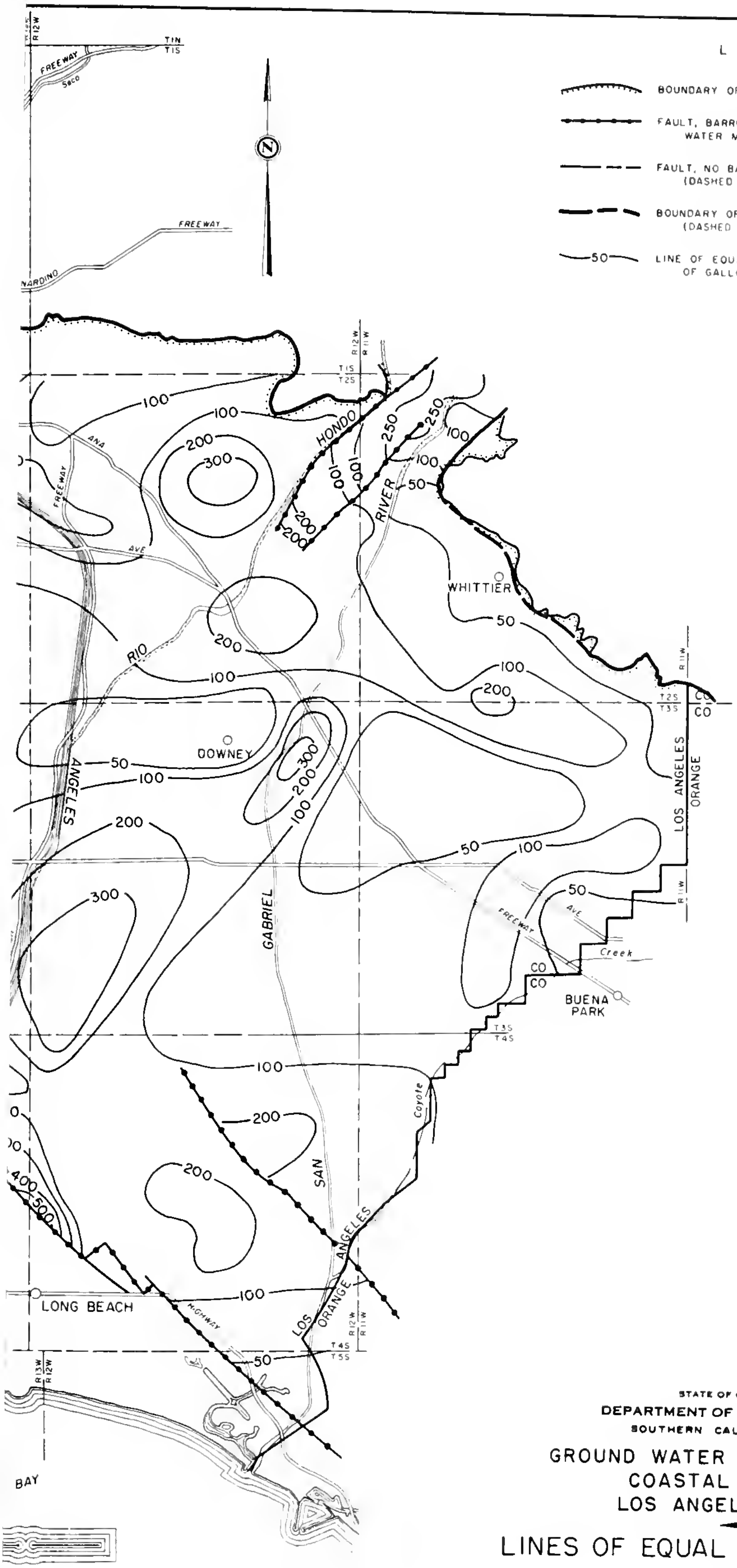
BOUNDARY OF WATER BEARING MATERIAL

FAULT, BARRIER OR PARTIAL BARRIER TO GROUND WATER MOVEMENT

FAULT, NO BARRIER TO GROUND WATER MOVEMENT (DASHED WHERE APPROXIMATELY LOCATED)

BOUNDARY OF SUNNYSIDE AQUIFER (DASHED WHERE APPROXIMATELY LOCATED)

—50— LINE OF EQUAL TRANSMISSIBILITY IN THOUSANDS OF GALLONS PER DAY PER FOOT OF WIDTH



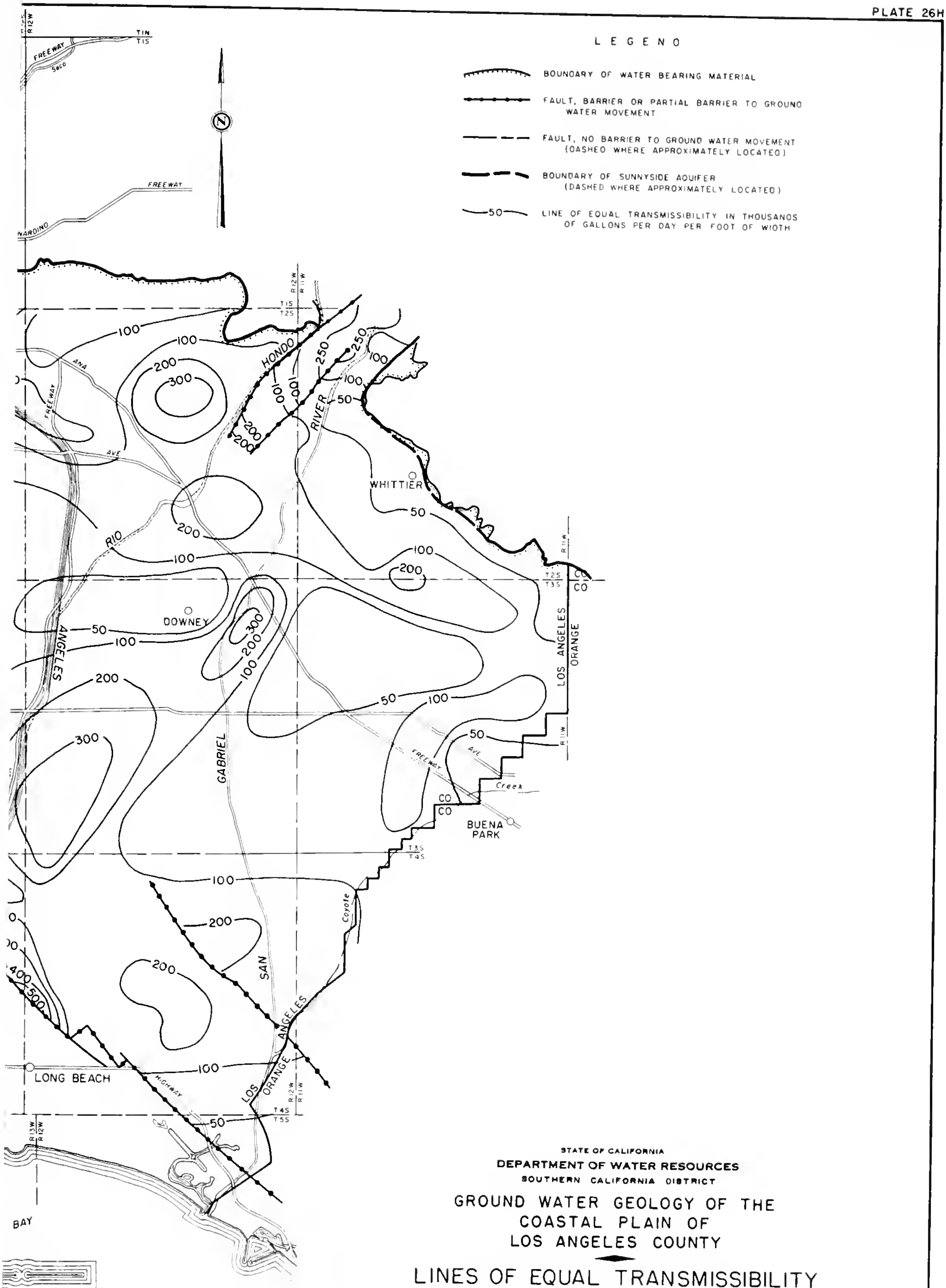
STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN CALIFORNIA DISTRICT

GROUND WATER GEOLOGY OF THE COASTAL PLAIN OF LOS ANGELES COUNTY

LINES OF EQUAL TRANSMISSIBILITY OF THE SUNNYSIDE AQUIFER

SCALE OF MILES
1 0 1 2 3

1961



STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN CALIFORNIA DISTRICT

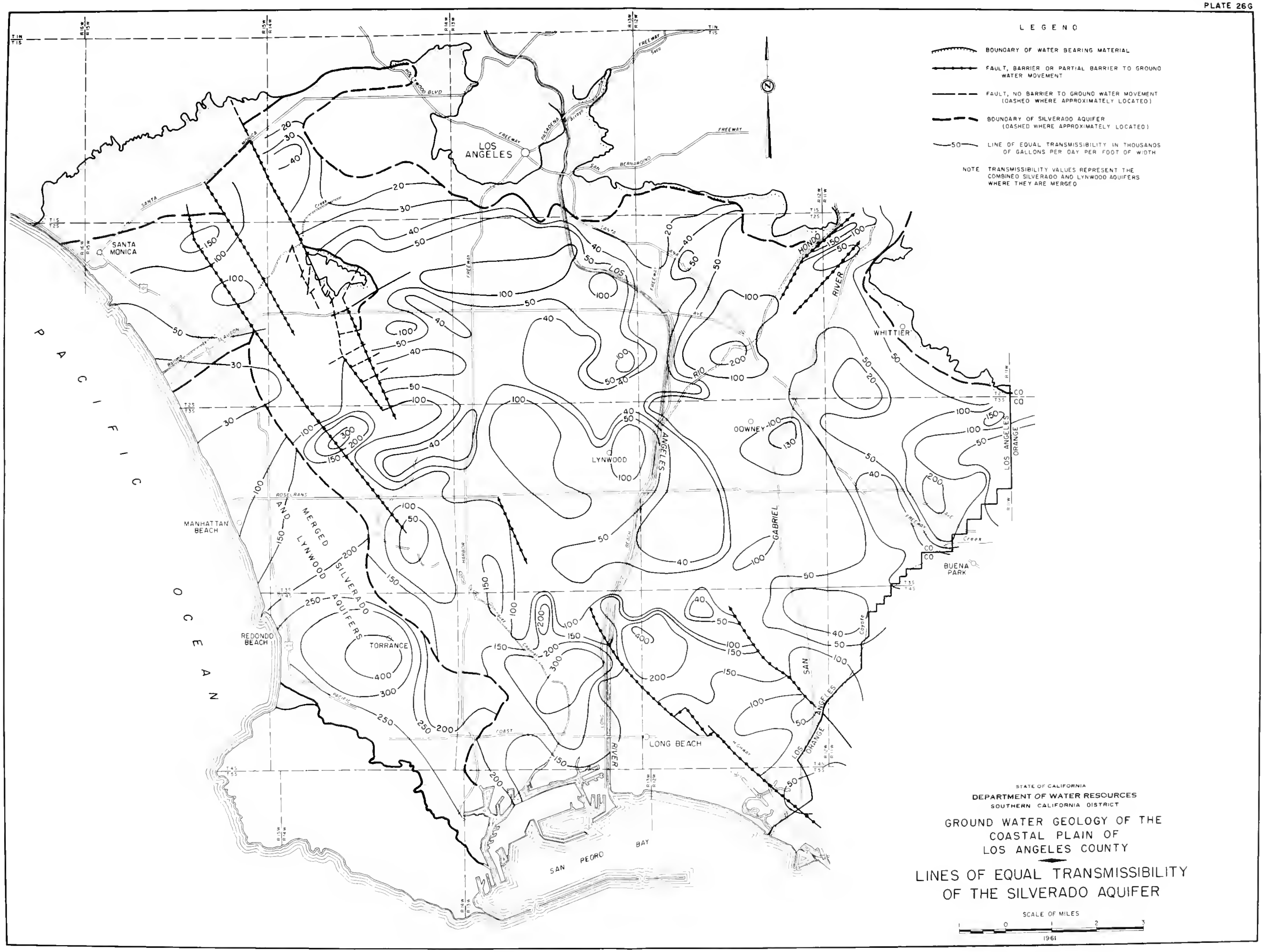
GROUND WATER GEOLOGY OF THE COASTAL PLAIN OF LOS ANGELES COUNTY

LINES OF EQUAL TRANSMISSIBILITY OF THE SUNNYSIDE AQUIFER

SCALE OF MILES

1 0 1 2 3

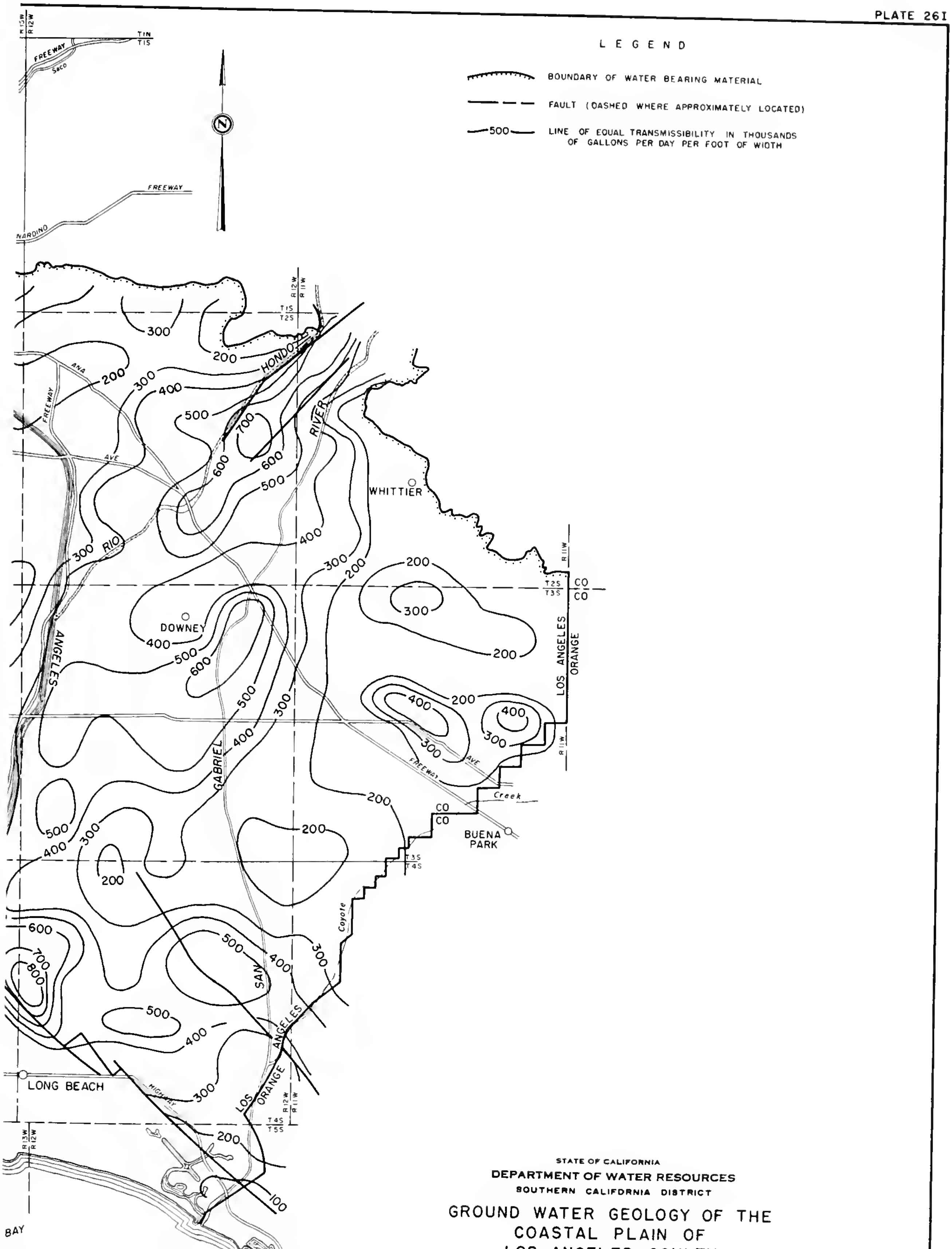
1961



STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN CALIFORNIA DISTRICT

GROUND WATER GEOLOGY OF THE COASTAL PLAIN OF LOS ANGELES COUNTY

LINES OF EQUAL TRANSMISSIBILITY OF THE SILVERADO AQUIFER

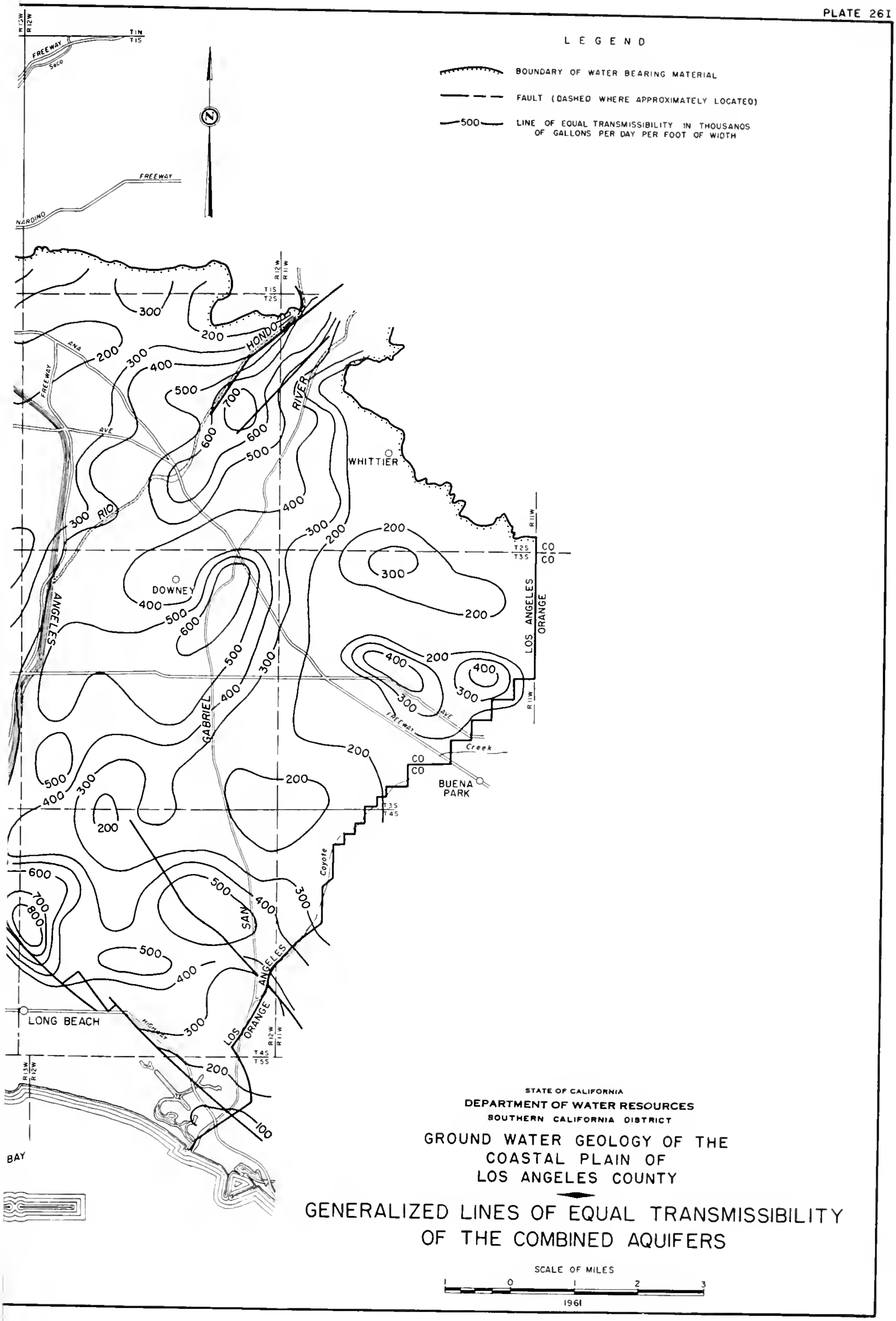


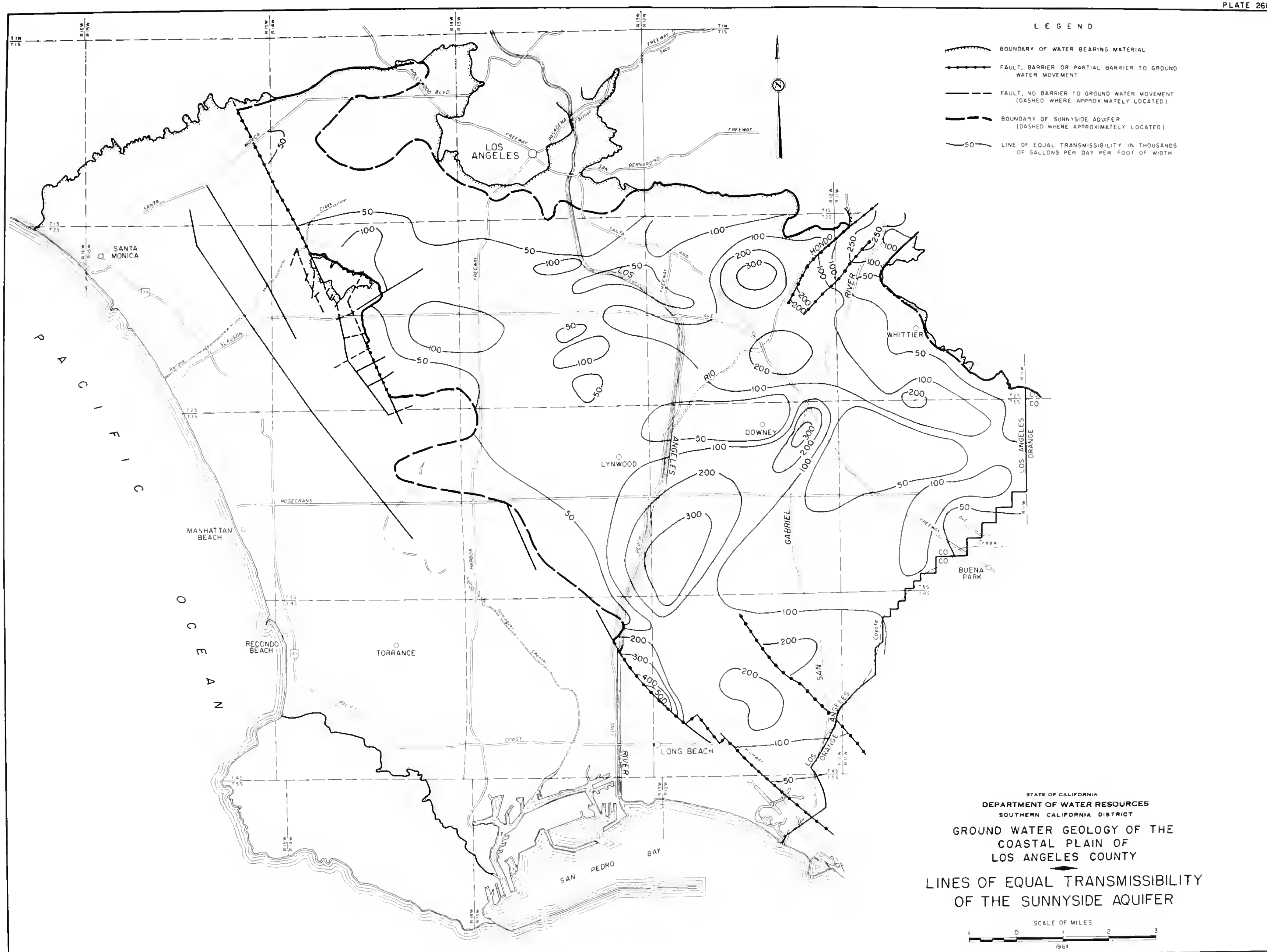
STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN CALIFORNIA DISTRICT

GROUND WATER GEOLOGY OF THE COASTAL PLAIN OF LOS ANGELES COUNTY

GENERALIZED LINES OF EQUAL TRANSMISSIBILITY OF THE COMBINED AQUIFERS

1961


LEGEND
BOUNDARY OF WATER BEARING MATERIAL
FAULT (DASHED WHERE APPROXIMATELY LOCATED)
500 LINE OF EQUAL TRANSMISSIBILITY IN THOUSANDS OF GALLONS PER DAY PER FOOT OF WIDTH
N
WHITTIER
DOWNEY
BUENA PARK
LONG BEACH
BAY
HONDO
RIVER
RIO
SAN GABRIEL
LOS ANGELES
ORANGE
Coyote
Creek
FREEWAY
HIGHWAY
AVE
T1N
T1S
T2S
T3S
T4S
T5S
R12W
R11W
R13W
CO
STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN CALIFORNIA DISTRICT
GROUND WATER GEOLOGY OF THE COASTAL PLAIN OF LOS ANGELES COUNTY
GENERALIZED LINES OF EQUAL TRANSMISSIBILITY OF THE COMBINED AQUIFERS
SCALE OF MILES
1 0 1 2 3
1961



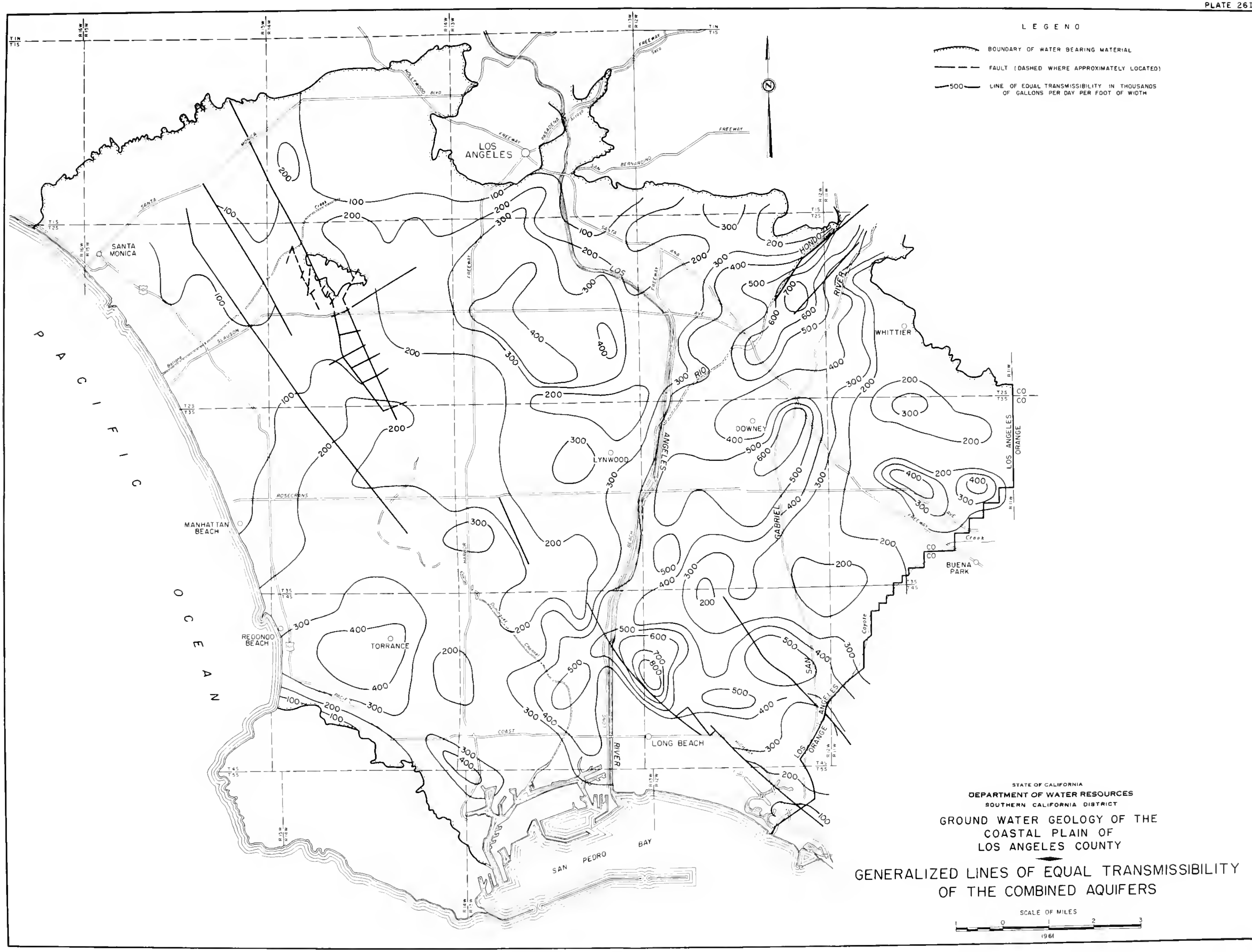
STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN CALIFORNIA DISTRICT

GROUND WATER GEOLOGY OF THE COASTAL PLAIN OF LOS ANGELES COUNTY

LINES OF EQUAL TRANSMISSIBILITY OF THE SUNNYSIDE AQUIFER

ATTACHMENT 1

BIBLIOGRAPHY


LEGEND
BOUNDARY OF WATER BEARING MATERIAL
FAULT (DASHED WHERE APPROXIMATELY LOCATED)
500 LINE OF EQUAL TRANSMISSIBILITY IN THOUSANDS OF GALLONS PER DAY PER FOOT OF WIDTH
STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN CALIFORNIA DISTRICT
GROUND WATER GEOLOGY OF THE COASTAL PLAIN OF LOS ANGELES COUNTY
GENERALIZED LINES OF EQUAL TRANSMISSIBILITY OF THE COMBINED AQUIFERS
SCALE OF MILES
1961
PACIFIC OCEAN
SANTA MONICA
LOS ANGELES
WHITTIER
DOWNEY
LYNWOOD
MANHATTAN BEACH
REDONDO BEACH
TORRANCE
LONG BEACH
BUENA PARK
SAN PEDRO BAY
LOS ANGELES RIVER
SAN GABRIEL RIVER
RIO HONDO
LOS ANGELES
ORANGE

ATTACHMENT 1

BIBLIOGRAPHY

ATTACHMENT 1

BIBLIOGRAPHY

* Asterisks indicate sources used in compilation of geologic map, Plate 3

American Association of Petroleum Geologists, Pacific Section. "A Guide to the Geology and Oil Fields of the Los Angeles and Ventura Regions". 1958.

The American Geological Institute. "Glossary of Geology and Related Sciences". The National Academy of Sciences - National Research Board Council, Washington, D. C. 1957.

*Bailey, T. L. and Jahns, R. H. "Geology of the Transverse Range Province, Southern California", California State Department of Natural Resources, Division of Mines. Bulletin 170, Chapter II, pp. 83-106. 1954.

Bandy, O. L. and Emery, K. O. "Geologic Guide for the Southwestern Part of the Los Angeles Basin, Southern California". California State Department of Natural Resources, Division of Mines. Bulletin 170, Geologic Guide No. 4. 1954.

Barbat, W. F. "The Los Angeles Basin Area, California, A Guide to the Geology and Oil Fields of the Los Angeles and Ventura Regions". American Association of Petroleum Geologists, Pacific Section. 1958.

Bowes, G. H. "Seal Beach Oil Field". California State Department of Natural Resources, Division of Mines. Bulletin No. 118, Chapter VIII, pp. 325-328. 1943.

Calif. D.W.R. in the text refers to the following 20 publications by years.

California State Department of Public Works, Division of Water Rights. "San Gabriel Investigation, Report for Period July 1, 1923, to September 30, 1926". Bulletin No. 5. 1927.

California State Department of Public Works, Division of Water Rights. "San Gabriel Investigation, Report for the Period October 1, 1926, to September 30, 1928". Bulletin No. 6. February, 1929a.

California State Department of Public Works, Division of Water Rights. "San Gabriel Investigation, Analysis and Conclusions". Bulletin No. 7. April, 1929b.

California State Department of Public Works, Division of Water Resources. "South Coastal Basin, A Symposium". Bulletin No. 32. 1930.

California State Department of Public Works, Division of Water Resources. "South Coastal Basin Investigation, Quality of Irrigation Waters". Bulletin No. 40. 1933a.

California State Department of Public Works, Division of Water Resources. "South Coastal Basin Investigation, Detailed Analyses Showing Quality of Irrigation Waters". Bulletin No. 40A. 1933b.

California State Department of Public Works, Division of Water Resources. "South Coastal Basin Investigation, Value and Cost of Water for Irrigation in Coastal Plain of Southern California". Bulletin No. 43. 1933c.

*California State Department of Public Works, Division of Water Resources. "South Coastal Basin Investigation, Geology and Ground Water Storage Capacity of Valley Fill". Bulletin No. 45. 1934.

California State Department of Public Works, Division of Water Resources. "South Coastal Basin Investigation, Overdraft on Ground Water Basins". Bulletin No. 53. 1947.

California State Department of Public Works, Division of Water Resources. "Sea-Water Intrusion into Ground Water Basins Bordering the California Coast and Inland Bays". Report No. 1. December, 1950.

*California State Department of Public Works, Division of Water Resources. "Report of Referee, California Water Service Company, a Corporation, et al., v. City of Compton, et al., Case No. 506806, Superior Court, Los Angeles County". June, 1952a.

California State Department of Public Works, Division of Water Resources. "Investigation of Los Angeles River". Code No. 52-4-2. September, 1952b.

California State Water Resources Board. "Central Basin Investigation, Lower Los Angeles and San Gabriel River Area, County of Los Angeles". Bulletin No. 8. March, 1952c.

California State Department of Public Works, Division of Water Resources. "South Coastal Basin Investigation, Records of Ground Water Levels at Wells". Bulletin No. 39 and annual supplements A through W. 1932 through 1956a.

California State Water Resources Board. "Los Angeles County Land and Water Use Survey, 1955". Bulletin No. 24. June, 1956b.

California State Department of Water Resources. "Water Supply Conditions in Southern California During 1955 and 1956". Bulletin No. 39-56. March, 1957a.

California State Department of Water Resources. "The California Water Plan". Bulletin No. 3. May, 1957b.

California State Department of Water Resources. "Water Supply Conditions in Southern California During 1956-57". Bulletin No. 39-57. June, 1958a.

California State Department of Water Resources. "Sea-Water Intrusion in California". Bulletin No. 63. November, 1958b.

California State Department of Water Resources. "Report on Proposed Central and West Basin Water Replenishment District". July, 1959.

Charlesworth, J. K. "The Quaternary Era with Special Reference to its Glaciation". Edward Arnold (Publishers) Ltd. London. 1957.

Clark, A. "The Cool-Water Timms Point Pleistocene Horizon at San Pedro, California". San Diego Society of Natural History Transactions, Vol. 7, No. 4, pp. 25-42. 1931.

Conrey, B. L. "Depositional and Sedimentary Patterns of Lower Pliocene-Repetto Rocks in the Los Angeles Basin", in a Guide to the Geology and Oil Fields of the Los Angeles and Ventura Regions. American Association of Petroleum Geologists, Pacific Section. 1958.

Corey, William H. "Tertiary Basin of Southern California". State of California, Department of Natural Resources, Division of Mines, Bulletin No. 170, Chapter III, pp. 73-83. 1954.

Crouch, J. A. "Paleontology and Paleo-ecology of San Pedro Shelf". Jour. Sed. Petrology, Volume 24, pp. 162-181. 1954.

*Daviess, S. N. and Woodford, A. O. "Geology of the Northwestern Puente Hills, Los Angeles County, California". United States Department of the Interior, Geological Survey. Oil and Gas Investigations, Preliminary Map 83. 1949.

Davis, E. L. "Torrance Oil Field". California State Department of Natural Resources, Division of Mines. Bulletin No. 118, Chapter VIII, pp. 298-300. 1943.

Delong, J. H., Jr. "The Paleontology and Stratigraphy of the Pleistocene at Signal Hill, Long Beach, California". Transactions San Diego Society of Natural History, Vol. IX, No. 25, pp. 229-252. 1941.

Driver, H. L. "Inglewood Oil Field". California State Department of Natural Resources, Division of Mines. Bulletin No. 118, Chapter VIII, pp. 306-309. 1943.

*Dudley, P. H. "East Coyote Area of the Coyote Hills Oil Field". California State Department of Natural Resources, Division of Mines. Bulletin No. 118, Chapter VIII, pp. 349-354. 1943.

*Durrell, C. "Geology of the Santa Monica Mountains, Los Angeles and Ventura Counties". California State Department of Natural Resources, Division of Mines. Bulletin 170, Map Sheet 8. 1954.

Eaton, J. E. "The Pleistocene in California". California State Department of Natural Resources, Division of Mines. Bulletin No. 118, Chapter VI, pp. 203-207. 1943.

Eckis, R. "Alluvial Fans of the Cucamonga District, Southern California". Journal of Geology, Vol. 36, No. 3, pp. 224-247. 1928.

*Eldridge, G. H. and Arnold, R. "The Santa Clara Valley, Puente Hills and Los Angeles Oil Districts, Southern California". United States Geological Survey. Bulletin 309. 1907.

Emery, K. O. and Rittenberg, S. C. "Early Diagenesis of California Basin Sediments in Relation to Origin of Oil". Bulletin American Association of Petroleum Geologists, Vol. 36, No. 5. 1952.

Emery, K. O. "General Geology of the Offshore Area, Southern California". California State Department of Natural Resources, Division of Mines. Bulletin 170, Chapter II, pp. 107-111. 1954.

Emery, K. O. "The Sea off Southern California". John Wiley and Sons, Inc. N. Y. 1960.

*English, W. A. "Geology and Oil Resources of the Puente Hills Region, Southern California". United States Geological Survey. Bulletin 768. 1926.

Fairbridge, R. W. "Dating the Latest of Movements of the Quaternary Sea Level". Trans. New York Academy of Science, Section II, Volume 20, pp. 471-482. 1958.

Fay, A. H. "Glossary of the Mining and Mineral Industry". United States Bureau of Mines. Bulletin 95. 1920.

Flint, Richard Foster. "Glacial and Pleistocene Geology", John Wiley & Sons, Inc., New York. 1957.

Gorsline, D. S. and Emery, K. O. "Turbidity Current Deposits in San Pedro and Santa Monica Basins Off Southern California". Bulletin Geological Society of America, Vol. 70, No. 3, pp. 279-290. 1959.

Grinsfelder, S. "Dominguez Oil Field". California State Department of Natural Resources, Division of Mines. Bulletin No. 118, Chapter VIII, pp. 318-319. 1943.

Hinds, Norman E. A. "Evolution of the California Landscape". California State Department of Natural Resources, Division of Mines. Bulletin 158, p. 26, 1952.

*Hoots, H. W. "Geology of the Eastern Part of the Santa Monica Mountains, Los Angeles County, California". United States Geological Survey Professional Paper 165-C. 1931.

Hopkins, David M. "Cenozoic History of the Bering Land Bridge", Science, Vol. 129, No. 3362, pp. 1519-1528. 1959.

*Hoskins, C. W. "Geology and Paleontology of the Coyote Hills, Orange County". Unpublished M. A. Thesis, Claremont Graduate School. 1954.

*Jahns, R. H. "Geology of the Peninsular Range Province, Southern California and Baja California". California State Department of Natural Resources, Division of Mines. Bulletin 170, Chapter II, pp. 29-52. 1954.

Jamison, H. C. and Malloy, R. J. "Boyle Heights Oil Field", A Guide to the Geology and Oil Fields of the Los Angeles and Ventura Regions, Pac. Sec. of American Association of Petrol. Geologists. 1958.

*Karubian, R. Y. "Surface and Subsurface Geology of Montebello Hills". Unpublished M. S. Thesis, California Institute of Technology. 1939.

*Kundert, C. J. "Geology of the Whittier - La Habra Area, Los Angeles County, California". California State Department of Natural Resources, Division of Mines. Special Report 18. 1952.

Larsen, E. S., Jr., Everhart, D. L. and Merriam, R. "Crystalline Rocks of Southeastern California". California State Department of Natural Resources, Division of Mines. Bulletin 159. 1951.

Larsen, E. S., Jr., Gottfried, David, Jaffe, Howard W., and Waring, Claude L. "Lead-Alpha Ages of the Mesozoic Batholiths of Western North America". United States Geological Survey Bulletin 1070-B. 1958.

Leverett, F. "The Weathered Zone (Sangamon) between the Iowan Loess and the Illinoian Till Sheet". Journal of Geology. Vol. 6, pp. 171-81. 1898.

Los Angeles County Flood Control District, Biennial Report on Hydrologic Data Seasons of 1955-56 and 1956-57, July 1, 1958.

Meinzer, O. "Hydrology". Dover Publications. New York. 1942.

Mendenhall, W. C. "Development of Underground Waters in the Central Coastal Plain Region of Southern California". United States Geological Survey Water Supply and Irrigation Paper No. 138. 1905a.

Mendenhall, W. C. "Development of Underground Waters in the Western Coastal Plain Region of Southern California". United States Geological Survey Water Supply and Irrigation Paper No. 139. 1905b.

Metzner, L. H. "Playa Del Rey Oil Field". California State Department of Natural Resources, Division of Mines. Bulletin No. 118, Chapter VIII, pp. 292-294. 1943.

Moore, David G. "The Marine Geology of San Pedro Shelf". Unpublished M. S. Thesis, University of California. 1951.

Moore, D. G. "Submarine Geology of the San Pedro Shelf", Jour. Sed. Petrology, Vol. 24 No. 3, pp. 162-181. 1954.

*Neuerburg, G. J. "Geology of the Griffith Park Area, Los Angeles County, California". California State Department of Natural Resources, Division of Mines. Special Report 33. 1953.

Piper, A. M., Garrett, A. A., and others. "Native and Contaminated Ground Waters in the Long Beach - Santa Ana Area, California". United States Geological Survey Open File Report. August, 1946.

Piper, A. M., Garrett, A. A., and others. "Native and Contaminated Ground Waters in the Long Beach - Santa Ana Area, California". United States Geological Survey Water Supply Paper 1136. 1953.

Poland, J. F., Piper, A. M., and others. "Geologic Features in the Coastal Zone of Long Beach - Santa Ana Area, California with Particular Respect to Ground Water Conditions". United States Geological Survey Open File Report. May, 1945.

Poland, J. F., Sollid, A. S., and others. "Ground Water Investigation along the Rio Hondo and Lower Los Angeles Rivers, Los Angeles County, California - Progress Report No. 1". United States Geological Survey Open File Report. January, 1946a.

Poland, J. F. and others. "Hydrology of the Long Beach - Santa Ana Area, California, with Special Reference to the Watertightness of the Newport-Inglewood Structural Zone". United States Geological Survey Open File Report. June, 1946b.

Poland, J. F., Garrett, A. A., and Sinnott, A. "Geology, Hydrology and Chemical Character of Ground Waters in the Torrance - Santa Monica Area, Los Angeles County, California". United States Geological Survey Open File Report. May, 1948.

*Poland, J. F., Piper, A. M., and others. "Ground Water Geology of the Coastal Zone Long Beach - Santa Ana Area, California". United States Geological Survey Water Supply Paper 1109. 1956.

*Poland, J. F., Garrett, A. A., and Sinnott A. "Geology, Hydrology, and Chemical Character of the Ground Waters in the Torrance - Santa Monica Area, California". United States Geological Survey Water Supply Paper 1461. 1959a.

Poland, J. F. and Sinnott, A. "Hydrology of the Long Beach - Santa Ana Area with Special Reference to the Watertightness of the Newport-Inglewood Structural Zone". United States Geological Survey Water Supply Paper 1471. 1959b.

*Quarles, M., Jr. "Geology of the Repetto and Montebello Hills". Unpublished M. S. Thesis, California Institute of Technology. 1940.

Reade, T. M. "The Post-Glacial Geology and Physiography of West Lancashire and the Mersey Estuary". Geological Magazine 9:111-119. 1872.

Reed, R. D. "Position of the California Oil Fields as Related to Geologic Structure". California State Department of Natural Resources, Division of Mines. Bulletin No. 118, Chapter IV, pp. 95-97. 1943a.

Reed, R. D. "California's Record in the Geologic History of the World". California State Department of Natural Resources, Division of Mines. Bulletin No. 118, Chapter V, pp. 99-118. 1943b.

Reese, R. G. "El Segundo Field". California State Department of Natural Resources, Division of Mines. Bulletin No. 118, Chapter VIII, pp. 295-296. 1943a.

Reese, R. G. "Lawndale Oil Field". California State Department of Natural Resources, Division of Mines. Bulletin No. 118, Chapter VIII, p. 297. 1943b.

Reese, R. G. "Montebello Area of the Montebello Oil Field". California State Department of Natural Resources, Division of Mines. Bulletin No. 118, Chapter VIII, pp. 340-342. 1943c.

Reese, R. G. "West Coyote Area of the Coyote Hills Oil Field". California State Department of Natural Resources, Division of Mines. Bulletin No. 118, Chapter VIII, pp. 347-348. 1943d.

Richter, R. C. "Geology of the West Basin, Los Angeles County, California". California State Department of Public Works, Division of Water Resources. Preliminary Report unpublished. 1950.

Riveroll, D. D. "The History of the Los Angeles Basin Drainage System Since Pliocene Time". Unpublished report, University of Southern California. 1957.

*Rodda, P. U. "Paleontology and Stratigraphy of Some Marine Pleistocene Deposits in Northwest Los Angeles Basin, California". Bulletin American Association of Petroleum Geologists, Vol. 41, No. 11, pp. 2475-2492. 1957.

Russell, R. J. "Instability of Sea Level". American Scientist, Vol. 45, No. 5, pp. 414-430. December, 1957.

Shelton, J. S. "Miocene Volcanism in Coastal Southern California". California State Department of Natural Resources, Division of Mines. Bulletin 170, Chapter VII, pp. 31-36. 1954.

Shepard, F. P. and Emery, K. O. "Submarine Topography off the California Coast: Canyons and Tectonic Interpretations." Geological Society of America Special Paper 31, 171 pp. 1941.

Shepard, F. P. "Submarine Geology". Harper & Brothers Publishers. New York. 1948.

Shepard, F. P. and Suess, H. E. "Rate of Postglacial Rise of Sea Level". Science, Vol. 123, No. 3207, pp. 1082-1083. 1956.

Slosson, J. E. "Lithofacies and Sedimentary - Paleogeographic Analysis of the Los Angeles Repetto Basin". Unpublished Ph.D. Thesis, University of Southern California. 1958.

Soper, E. K. "Beverly Hills Oil Field". California State Department of Natural Resources, Division of Mines. Bulletin No. 118, Chapter VIII, p. 287. 1943a.

Soper, E. K. "Los Angeles City Oil Field". California State Department of Natural Resources, Division of Mines. Bulletin No. 118, Chapter VIII, pp. 282-283. 1943b.

Soper, E. K. "Salt Lake Oil Field". California State Department of Natural Resources, Division of Mines. Bulletin No. 118, Chapter VIII, pp. 284-286. 1943c.

*Stark, H. E. "Geology and Paleontology of the Northern Whittier Hills, California". Unpublished M. A. Thesis, Claremont Graduate School. 1949.

Stevenson, R. E., Uchupi, E., and Gorsline, D. S. "Some Characteristics of Sediments on the Mainland Shelf of Southern California". Oceanographic Survey of the Continental Shelf Area of Southern California. Allan Hancock Foundation for Scientific Research, University of Southern California, pp. 65-109. October, 1958.

Stolz, H. P. "Long Beach Oil Field". California State Department of Natural Resources, Division of Mines. Bulletin No. 118, Chapter VIII, pp. 320-324. 1943a.

Stolz, H. P. and Woodward, A. W. "West Montebello Area of the Montebello Oil Field". California State Department of Natural Resources, Division of Mines. Bulletin No. 118, Chapter VIII, pp. 335-339. 1943b.

Terry, R. D., Keesling, S. A., and Uchupi, E. "Submarine Geology of Santa Monica Bay, California". A Final Report Submitted to Hyperion Engineers, Inc., by the Geology Department, University of Southern California. 1956.

Tolman, C. F. "Ground Water". McGraw-Hill Co. New York. 1937.

*Troxel, B. W. "Geologic Guide for the Los Angeles Basin, Southern California". California State Department of Natural Resources, Division of Mines. Bulletin 170, Geologic Guide No. 3. 1954.

Willis, R. and Ballantyne, R. S., Jr. "Potrero Oil Field". California State Department of Natural Resources, Division of Mines. Bulletin No. 118, Chapter VIII, pp. 310-317. 1943.

Winter, H. E. "Santa Fe Springs Oil Field". California State Department of Natural Resources, Division of Mines. Bulletin No. 118, Chapter VIII, pp. 343-346. 1943.

Winterburn, R. "Wilmington Oil Field". California State Department of Natural Resources, Division of Mines. Bulletin No. 118, Chapter VIII, pp. 301-305. 1943.

Wissler, S. G. "Stratigraphic Formations of the Producing Zones of the Los Angeles Basin Oil Fields". California State Department of Natural Resources, Division of Mines. Bulletin No. 118, Chapter VII, pp. 209-234. 1943.

*Woodford, A. O., Schoellhamer, J. E., Veddar, J. G., and Yerkes, R. F. "Geology of the Los Angeles Basin". California State Department of Natural Resources, Division of Mines. Bulletin 170, Chapter II, pp. 65-81. 1954.

*Woodring, W. P., Bramlette, M. N., and Kew, W. S. W. "Geology and Paleontology of Palos Verdes Hills, California". United States Geological Survey Professional Paper 207. 1946.

Selected References Used in Computation of Transmissibility and Storage Coefficients from Well Tests

Cooper, H. H., Jr. and Jacob, C. E. "A Generalized Graphical Method for Evaluating Formation Constants and Summarizing Well-Field History". Transaction American Geophysical Union, Vol. 27, No. 4, pp. 526-534. August 1946.

Glover, R. E., McDonald, H. K., Tapp, W. N., and Moody, W. T. United States Bureau of Reclamation memorandum titled "Analysis of Pump Tests Nos. 1 to 9 - James Division - Missouri River Basin Project", Denver, Colorado, February 12, 1952.

Hantush, Mahdi, S. "Analysis of Data from Pumping Tests in Leaky Aquifers". Transactions American Geophysical Union, Vol. 37, No. 6, pp. 702-714. 1956.

Theis, C. V. "The Relation between the Lowering of the Piezometric Surface and the Rate and Duration of Discharge of a Well Using Ground Water Storage". Transactions American Geophysical Union, pp. 519-524, August 1935.

Walton, William C. "Leaky Artesian Aquifer Conditions in Illinois". Illinois State Water Survey Report of Investigation 39. 1960.

Wenzel, L. K. "Methods for Determining Permeability of Water-Bearing Materials". United States Geological Survey Water Supply Paper 887, 1942.

ATTACHMENT 2

SPECIFIC YIELD VALUES AND

TRANSMISSIBILITY TESTS

ATTACHMENT 2

TABLE OF CONTENTS

TABLE A

SPECIFIC YIELD VALUES
Used in Coastal Plain of Los Angeles County

(After State Water Rights Board Revised Values of Specific Yield as used for San Fernando Valley Reference, 7/9/59, which is based on values used in Bulletin 45, Geology and Ground Water Storage Capacity of Valley Fill)
*Specific yield values above base of Bellflower aquiclude = 00

*00 Percent - Bellflower Aquiclude

03 Percent - Clay and Shale

Adobe	Granite clay	Shale
Boulders in clay	Hard clay	Shaley clay
Cemented clay	Hard pan	Shell rock
Clay	Hard sandy shale	Silty clay loam
Clayey loam	Hard shell	Soapstone
Decomposed shale	Muck	

05 Percent - Clayey Sand and Silt

Chalk rock	Rotten conglomerate	Sediment
Clay and gravel	Rotten granite	Shaley gravel
Clayey sand	Sand and clay	Silt
Clayey silt	Sand and silt	Silty clay
Conglomerate	Sand rock	Silty loam
Decomposed granite	Sandstone	Silty sand
Gravelly clay	Sandy clay	Soil
Loam	Sandy silt	

10 Percent - Cemented or Tight Sand or Gravel

Caliche	Dead gravel	Heavy rocks
Cemented boulders	Dead sand	Soft sandstone
Cemented gravel	Dirty pack sand	Tight boulders
Cemented sand	Hard gravel	Tight coarse gravel
Cemented sand and gravel	Hard sand	

14 Percent - Gravel and Boulders

Cobbles and gravel	Heaving gravel	Silty sand
Coarse gravel	Heavy gravel	Tight fine gravel
Boulders	Large gravel	Tight medium gravel
Broken rocks	Rocks	Muddy sand
Gravel and boulders	Sand and gravel, silty	

SPECIFIC YIELD VALUES
(continued)

16 Percent - Fine Sand

Fine sand	Quicksand	Sand, gravel and boulders
Heaving sand	Sand and boulders	Tight sand

21 - 23 Percent - Sand and Gravel

Dry gravel	Gravelly sand	Sand
Loose gravel	Medium gravel	Water gravel

26 Percent - Coarse Sand and Fine Gravel

Coarse sand	Fine gravel	Medium sand

Value of one added to given value where streaks of sand or gravel occur in clay or clayey material.

TABLE B

ESTIMATED AVERAGE SPECIFIC YIELD VALUES[1] BY ELEVATIONAL INCREMENTS, COASTAL PLAIN OF LOS ANGELES COUNTY

SANTA MONICA BASIN

(IN PERCENT)

LOCATION[2]	ELEVATIONAL INCREMENTS IN FEET ABOVE SEA LEVEL																								
	320 300	300 280	280 260	260 240	240 220	220 200	200 180	180 160	160 140	140 120	120 100	100 80	80 60	60 40	40 20	20 0	0 -20	-20 -40	-40 -60	-60 -80	-80 -100	-100 -120	-120 -140	-140 -160	-160 -180	-180 -200
1/14-30											23	14	14	14	14	10	9	9	9	9	9	9	9	9	9	9
1/14-31											9	21	19	19	19	16	13	5	21	23	23	23	24	26	26	26
1/15-14						5	5	4	5	6	8	6	6	5	4	4	5	5	5	5	10	4	3	3	5	6
1/15-15	5	5	4	5	6	8	6	6	5	4	4	5	5	5	5	10	4	3	3	5	6	6	6	6	6	6
1/15-19	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5					
1/15-20	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5		
1/15-21	3	3	3	3	5	10	15	15	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12
1/15-22	3	3	3	3	20	19	5	13	22	25	19	23	19	11	12	12	12	12	12	12	12	12	12	12	12	12
1/15-23			2	3	3	3	3	3	26	13	5	15	25	25	19	23	15	12	12	12	12	12	12	12	12	12
1/15-24					4	6	5	5	6	5	4	2	3	16	8	5	10	15	17	12	15	10	4	5	5	5
1/15-25					12	19	14	14	14	12	10	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12
1/15-26					12	19	14	14	14	12	10	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12
1/15-27				17	23	23	13	5	23	13	3	3	3	3	5	10	15	14	11	11	11	11	11	11	11	11
1/15-28	6	23	23	13	13	15	23	3	3	3	3	3	9	10	18	8	8	8	8	8	8	8	8	8	8	8
1/15-29				2	5	6	4	4	4	4	4	4	4	4	3	3	3	3	3	3	3	4	3	3	8	5
1/15-30			6	6	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
1/15-31						4	5	5	4	4	4	4	4	4	4	4	3	3	3	3	3	3	3	4	3	5
1/15-32							3	7	8	5	10	12	12	10	9	7	4	3	7	6	7	4	4	4	4	4
1/15-33									20	23	21	13	7	23	11	3	3	3	3	6	10	12	12	12	12	12
1/15-34								23	23	18	13	10	23	8	3	3	3	3	7	10	18	13	13	13	13	13
1/15-35									17	23	23	13	5	23	13	3	3	3	3	5	10	15	15	12	12	12
1/15-36					12	19	14	14	14	12	10	14	14	14	14	14	14	14	14	14	14					
1/16-25		9	5	5	5	5	5	5	5	5	5	5	5	5	5	5										
1/16-26			4	3	3	5	8	3	3	3	3	3	3	3	3	3										
1/16-35								4	3	3	5	8	3	3	3	3										
1/16-36										5	3	4	5	8	3	10										
2/14-05											2	2	3	12	10	9	8	8	9	8	11	11	13	15	12	9
2/14-06														20	17	9	5	5	5	5	5					
2/14-07															18	18	9	5	5	5	5	5				
2/14-08														3	5	5	5	5	5	5	5					
2/14-17			6	14	12	10	12	20	19	12	13	15	5	5	5	5	5	4	5	5	15	11	6	3	3	3
2/14-18									2	3	6	4	12	12	10	17	19	22	22	19	15	15	13	10	7	8
2/14-19														2	2	5	15	18	10	12	9	9	14	14	16	14
2/15-01													1	12	9	7	5	5	5	5	5					
2/15-02													2	5	4	4	4	4	4	7	15					

(Continued)

ESTIMATED AVERAGE SPECIFIC YIELD VALUES[1] BY ELEVATIONAL INCREMENTS, COASTAL PLAIN OF LOS ANGELES COUNTY
SANTA MONICA BASIN (CONTINUED)
(IN PERCENT)

LOCATION[2]	ELEVATIONAL INCREMENTS IN FEET ABOVE SEA LEVEL																									
	320 300	300 280	280 260	260 240	240 220	220 200	200 180	180 160	160 140	140 120	120 100	100 80	80 60	60 40	40 20	20 0	0 -20	-20 -40	-40 -60	-60 -80	-80 -100	-100 -120	-120 -140	-140 -160	-160 -180	-180 -200
2/15-03											2	14	16	13	11	12	14	4	4	5	9	14	17	14	13	5
2/15-04										4	15	15	11	16	19	15	13	13	3	3	4	10	12	18	12	12
2/15-05											5	8	20	17	12	13	14	23	14	14	14					
2/15-06												1	12	12	20	19	21	13	14							
2/15-07															12	13										
2/15-08									5	17	17	17	17	18	18	20	23	21	21	21	21					
2/15-09																13	23	22	17	16	16	18	18	18		
2/15-10											7	12	10	16	15	12	12	10	13							
2/15-11													9	7	10	15	14	11	12	13	18	18	17	21	22	19
2/15-12															2	11	12	8	5	4	4	8	8	12	15	
2/15-13															1	7	18	12	11	11	10	13	14	11	9	11
2/15-14																9	9	15	18	18	17	17	19	17	17	14
2/15-15														1	6	13	11	11	17	21	15	12	11	10	16	12
2/15-16																11	15	13	21	21	22	21	18	18	20	20
2/15-17															5	15	16	16	18	21	18	16	15	5	11	14
2/15-18																17	23	23	23	21	21					
2/15-20																	14	12	15	18	22	20	16	16		
2/15-21																	21	19	15	19	19	20	16	14	14	11
2/15-22																2	11	14	18	20	17	17	14	16	11	5
2/15-23																1	5	11	18	20	19	17	11	9	7	8
2/15-24																	6	17	18	13	11	9	11	13	11	18
2/15-26																	2	8	16	13	11	10	9	9	9	8
2/15-27																		1	9	5	3	4				
2/15-28																8	16	16	16	16	16					
2/15-33																3	5	5	5							
2/16-01												13	14	22	11	12										
2/16-02									1	20	17	15	14	14	14	14										
2/16-12														21	23	10										

(Continued)

ESTIMATED AVERAGE SPECIFIC YIELD VALUES[1] BY ELEVATIONAL INCREMENTS, COASTAL PLAIN OF LOS ANGELES COUNTY

WEST COAST BASIN

(IN PERCENT)

LOCATION[2]	ELEVATIONAL INCREMENTS IN FEET ABOVE SEA LEVEL																									
	320 300	300 280	280 260	260 240	240 220	220 200	200 180	180 160	160 140	140 120	120 100	100 80	80 60	60 40	40 20	20 0	0 -20	-20 -40	-40 -60	-60 -80	-80 -100	-100 -120	-120 -140	-140 -160	-160 -180	-180 -200
2/14-08														3	5	5	5	5	5	5	5					
2/14-16				2	2	3	2	12	17	13	9	11	15	3	11	6	13	10	13	9	3					
2/14-17			6	14	12	10	12	20	19	12	13	15	5	5	5	5	5	4	5	5	15	11	6	3	3	3
2/14-18									2	3	6	4	12	12	10	17	19	22	22	19	15	15	13	10	7	8
2/14-19														2	2	5	15	18	10	12	9	9	14	14	16	14
2/14-20									5	5	4	3	3	22	19	3	14	15	9	5	5	5	4			
2/14-21									5	4	5	6	10	17	18	13	17	8	10	16	13	5	5	3	10	10
2/14-22										1	4	11	15	15	16	15	13	11	12	3	6	13	10	6	4	5
2/14-27								1	3	6	8	13	14	11	12	12	10	11	11	11	10	11	11	9	8	7
2/14-28								5	10	10	11	11	12	13	14	14	15	15	15	13	13	12	12	13	13	11
2/14-29																	7	16	13	16	5	3	3	7	23	11
2/14-30												1	1	2	6	2	9	9	9	12	12	12	13	19	15	10
2/14-31																			3	13	11	9	23	13	3	3
2/14-32																			5	15	22	12	11	8	4	5
2/14-33																2	12	7	7	18	16	18	10	3	10	10
2/14-34											2	9	18	19	15	15	11	8	8	8	8	15	18	20	19	14
2/15-24																	6	17	18	13	11	9	11	13	11	18
2/15-25																	17	23	15	23	23	18	18	18	18	18
2/15-26																	2	8	16	13	11	10	9	9	9	8
2/15-27																		1	9	5	3	4				
2/15-33																3	5	5	5							
2/15-34										1	4	4	8	8	6	9	9	18	18	14	14					
2/15-35											8	23	23	23	23	22	23	22	18	22	21	16	16	18	16	
2/15-36											3	8	8	8	12	15	14	9	13	20	13	14	14	11	10	3
3/13-17												1			1	6	10	8	11	8	10	12	13	9	11	15
3/13-18													1	1	2	5	4	4	9	8	11	9	14	13	15	18
3/13-19																4	7	6	9	11	10	11	11	12	17	14
3/13-20															1	1	7	18	17	15	11	8	17	10	9	6
3/13-28												4	5	5	6	6										
3/13-29																1	1	5	8	7	10	11	15	9	14	10
3/13-30															2	2	2	2	2	4	6	9	13	13	8	9
3/13-31																					6	8	6	13	9	10
3/13-32															1	1	1	1	1	1	2	6	5	3	3	4
3/13-33													9	15	16	16	14	16	15	16	17	12	11	15	4	4
3/13-34													1	5	13	17	7	8	10	9	10	16	9	14	17	18

(Continued)

ESTIMATED AVERAGE SPECIFIC YIELD VALUES[1] BY ELEVATIONAL INCREMENTS, COASTAL PLAIN OF LOS ANGELES COUNTY

WEST COAST BASIN (CONTINUED)

(IN PERCENT)

LOCATION[2]	ELEVATIONAL INCREMENTS IN FEET ABOVE SEA LEVEL																									
	320 300	300 280	280 260	260 240	240 220	220 200	200 180	180 160	160 140	140 120	120 100	100 80	80 60	60 40	40 20	20 0	0 -20	-20 -40	-40 -60	-60 -80	-80 -100	-100 -120	-120 -140	-140 -160	-160 -180	-180 -200
3/14-02											1	7	6	8	9	12	9	12	8	9	12	9	9	11	8	8
3/14-03														3	1	1	4	6	9	5	8	9	5	9	8	8
3/14-04																			10	18	16	11	8	12	9	4
3/14-05																			2	16	20	22	20	20	20	20
3/14-06																			17	17	18	19	17	17	17	17
3/14-07															1	5	11	13	15	14	14	10	10	9	10	12
3/14-08																	5	18	14	10	8	5	6	10	13	15
3/14-09																3	7	12	12	17	12	10	11	14	10	9
3/14-10													1	4	4	4	4	4	4	4	4	8	16	12	15	14
3/14-11											2	3	1	3	3	2	6	10	15	10	7	8	12	21	20	22
3/14-12										1	4	9	15	16	15	14	17	21	16	15	15	8	9	11	15	12
3/14-13														2	7	4	4	6	10	12	10	7	8	14	13	12
3/14-14																				2	7	11	5	8	8	12
3/14-15																		7	7	6	10	14	7	4	22	17
3/14-16															1	4	4	2	6	9	13	12	13	14	7	5
3/14-17																	3	11	10	10	10	6	4	4	4	9
3/14-18																		8	14	9	19	18	5	5	10	10
3/14-19														3	5	5	5	5	5	7	12	10	15	18	21	17
3/14-20																							23	14	5	5
3/14-21																				9	13	10	9	8	9	7
3/14-22																				5	9	12	12	15	12	7
3/14-23																					2	6	11	14	8	6
3/14-24														2	3	3	3	3	3	3	3	5	9	11	15	16
3/14-25																					4	16	19	16	13	10
3/14-26																					4	14	18	18	16	15
3/14-27																				4	11	17	21	18	16	8
3/14-28																3	4	4	9	15	15	17	15	11	12	15
3/14-29																		3	10	7	14	19	20	18	17	16
3/14-30																			4	11	13	14	18	16	13	12
3/14-31																		1	9	18	14	22	21	21	21	23
3/14-32																		6	21	23	23	9	19	23	23	23
3/14-33																		3	13	14	18	13	14	13	13	13
3/14-34																			9	14	18	17	16	17	12	9
3/14-35																			4	10	16	13	12	7	5	6
3/14-36																				1	4	7	6	5	5	6

(Continued)

ESTIMATED AVERAGE SPECIFIC YIELD VALUES[1] BY ELEVATIONAL INCREMENTS, COASTAL PLAIN OF LOS ANGELES COUNTY

WEST COAST BASIN (CONTINUED)

(IN PERCENT)

LOCATION[2]	ELEVATIONAL INCREMENTS IN FEET ABOVE SEA LEVEL																									
	320 300	300 280	280 260	260 240	240 220	220 200	200 180	180 160	160 140	140 120	120 100	100 80	80 60	60 40	40 20	20 0	0 -20	-20 -40	-40 -60	-60 -80	-80 -100	-100 -120	-120 -140	-140 -160	-160 -180	-180 -200
3/15-01											10	12	12	12	10	16	20	13	7	7	11	13	13	13	13	14
3/15-02											4	16	16	16	16	16	11	20	17	18	15	19	20	16		
3/15-03													12	20	20	19	19	16	7	22	17					
3/15-10													8	16	8	8	20	24	9							
3/15-11												19	16	18	15	13	15	17	15	21	14	5				
3/15-12																2	3	10	8	12	10	14	14	14	13	12
3/15-13								1	6	7	7	6	6	6	6	5	5	5	11	10	12	11	13	16	12	14
3/15-14											16	22	22	22	22	22	19	14	5	18						
3/15-23														7	20	20	19	19	18	8	19					
3/15-24												8	8	8	11	10	3	5	13	14	23	19	14	12	11	
3/15-25																	1	2	8	14	14	15	13	12	9	
3/15-36																			14	14	14	14	14	14	14	14
4/13-02														1	3	5	13	19	20	17	9	9	10	4	9	12
4/13-03																			3	16	18	16	9	3	3	3
4/13-04																						6	3	3	10	4
4/13-05																										8
4/13-06																			12	12	12	12	12	12	12	12
4/13-07																			1	2	6	12	16	13	9	4
4/13-08																				1	3	7	9	13	8	10
4/13-09																				2	7	8	2	2	2	6
4/13-10																	2	5	6	5	13	14	10	9	8	6
4/13-11																	2	13	14	17	8	10	9	9	9	9
4/13-14																1	1	5	14	17	23	23	15	21	18	23
4/13-15																	2	6	11	19	17	14	7	7	8	8
4/13-16															1	5	5	5	5	5	5	5	6	15	13	13
4/13-17									20	23	22	16	23	23	12	12	8	5	5	5	2	6	13	13	11	11
4/13-18																								4	8	21
4/13-19																				11	13	7	11	10	11	20
4/13-20																				1	12	16	11	19	21	21
4/13-21																					11	15	15	15	17	16
4/13-22																		2	3	4	6	5	15	16	12	13
4/13-23																		3	8	17	18	17	22	10	14	10
4/13-24																			5	14	15	8	18	8	9	6
4/13-25																2	3	2	4	6	12	16	21	19	17	16
4/13-26																	5	5	8	21	17	21	19	23	23	23

(Continued)

ESTIMATED AVERAGE SPECIFIC YIELD VALUES[1] BY ELEVATIONAL INCREMENTS, COASTAL PLAIN OF LOS ANGELES COUNTY

WEST COAST BASIN (CONTINUED)

(IN PERCENT)

LOCATION[2]	ELEVATIONAL INCREMENTS IN FEET ABOVE SEA LEVEL																									
	320 300	300 280	280 260	260 240	240 220	220 200	200 180	180 160	160 140	140 120	120 100	100 80	80 60	60 40	40 20.	20 0	0 -20	-20 -40	-40 -60	-60 -80	-80 -100	-100 -120	-120 -140	-140 -160	-160 -180	-180 -200
4/13-27																2	3	3	3	8	12	13	12	13	11	12
4/13-28																					5	8	17	17	23	23
4/13-29																		4	6	13	20	16	15	17	23	23
4/13-30																		2	7	12	12	10	10	7	14	20
4/13-31																	4	6	14	13	10	9	10	8	12	12
4/13-32																			5	8	11	20	14	7	8	10
4/13-33																					1	4	9	6	5	4
4/13-34																					16	12	3	10	23	23
4/13-35																			5	18	18	14	13	12	12	12
4/14-01																				1	4	16	12	4	3	3
4/14-02																		3	6	11	19	22	13	13	13	9
4/14-03																		3	13	19	18	20	22	23	22	22
4/14-04																		8	20	9	5	14	19	18	20	21
4/14-05											13	23	23	22	18	23	23	9	21	19	19	20	20	20	20	20
4/14-06																	9	8	18	19	19	16	16	24	26	18
4/14-07												2	3	3	4	8	12	12	10	10	18	19	21	21	21	21
4/14-08									8	12	14	16	16	15	14	16	19	20	19	21	19	20	22	20	19	18
4/14-09																		7	21	13	8	26	24	21	21	21
4/14-10																2	11	18	13	18	21	22	22	22	21	18
4/14-11																5	12	17	18	19	21	18	18	9	11	10
4/14-12																					2	3	3	4	3	3
4/14-13															2	3	12	18	21	15	20	15	13	12	3	8
4/14-14																	10	16	16	16	16	16	18	16	17	26
4/14-15																1	1	5	5	6	5	10	6	12	16	16
4/14-16													1	5	10	14	17	15	14	13	14	16	15	21	20	21
4/14-17												2	7	9	17	14	18	19	13	12	22	19	23	21	20	19
4/14-18																			1	16	16	22	22	22	21	15
4/14-19																			4	5	5	8	13	10	12	21
4/14-20											7	23	9	12	10	13	17	17	18	18	5	4	7	21	23	16
4/14-21												3	4	5	12	19	17	15	16	19	20	18	18	17	19	18
4/14-22														1	6	9	13	15	16	19	16	15	16	17	19	20
4/14-23														1	12	17	16	18	19	18	18	19	18	16	15	10
4/14-24													5	5	5	10	16	22	23	19	16	13	13	11	9	20
4/14-25															5	8	9	11	16	16	16	16	15	12	13	14
4/14-26																1	2	5	5	10	14	12	14	16	16	7

(Continued)

ESTIMATED AVERAGE SPECIFIC YIELD VALUES[1] BY ELEVATIONAL INCREMENTS, COASTAL PLAIN OF LOS ANGELES COUNTY

WEST COAST BASIN (CONTINUED)

(IN PERCENT)

LOCATION[2]	ELEVATIONAL INCREMENTS IN FEET ABOVE SEA LEVEL																									
	320 300	300 280	280 260	260 240	240 220	220 200	200 180	180 160	160 140	140 120	120 100	100 80	80 60	60 40	40 20	20 0	0 -20	-20 -40	-40 -60	-60 -80	-80 -100	-100 -120	-120 -140	-140 -160	-160 -180	-180 -200
4/14-27								8	7	6	5	4	3	3	6	9	13	15	16	16	16	10	15	19	19	18
4/14-28							1	2	3	4	3	5	3	5	6	10	16	18	18	21	21	20	22	22	15	17
4/14-29															4	2	2	3	7	7	8	15	14	13	17	22
4/14-34			3	5	5	5	5	23	23	23	23	18	3	3	12	12	12	12	12	12	12	12	12	12	12	12
4/14-35			5	5	5	5	6	13	11	15	15	15	17	17	17	18	20	21	19	18	19	16	15	17	19	18
4/14-36															4	4	10	12	11	10	11	16	16	17	18	18
4/15-01																			2	11	7	16	17	23	12	21
5/13-02																					1	3	4	19	25	14
5/13-03																			1	6	16	18	17	14	16	11
5/13-04																					12	19	14	12	12	3
5/13-05																			12	5	10	16	9	8	8	3
5/13-06																5	4	3	18	8	7	9	4	4	4	4
5/13-07																			23	9	9	12	3	3	3	3
5/13-08																			12	5	10	16	9	8	8	3
5/13-09																					21	20	14	13	13	3
5/13-10																					12	10	8	9	7	10
5/13-11																						1	3	3	4	18
5/13-17																					4	13	10	10	9	7
5/13-18																				8	13	10	9	8	8	9
5/14-01																14	11	5	4	10	6	5	5	5	5	
5/14-02									3	5	4	6	10	12	13	14										
5/14-11				2	3	3	3	3	3	3	3	3	3	3	3	3										
5/14-12												4	6	4	7	7										
5/14-13									2	3	10	7	6	6	10	10										

(Continued)

ESTIMATED AVERAGE SPECIFIC YIELD VALUES[1] BY ELEVATIONAL INCREMENTS, COASTAL PLAIN OF LOS ANGELES COUNTY

HOLLYWOOD BASIN

(IN PERCENT)

LOCATION[2]	ELEVATIONAL INCREMENTS IN FEET ABOVE SEA LEVEL																									
	320 300	300 280	280 260	260 240	240 220	220 200	200 180	180 160	160 140	140 120	120 100	100 80	80 60	60 40	40 20	20 0	0 -20	-20 -40	-40 -60	-60 -80	-80 -100	-100 -120	-120 -140	-140 -160	-160 -180	-180 -200
1/13-07					5	7																				
1/13-18							2	7	7																	
1/14-02					3	16																				
1/14-07	5	5	4	5	5	6	6	6	5	4	4	5	5	5	5	10	4	3	3	5	6					
1/14-08											11	11	11	11	11	11	11	11	11							
1/14-09												11	16	16	18	26	26	26	26							
1/14-10										3	16	16	16	23	26	26										
1/14-11				2	3	3	4	3	3																	
1/14-12					3	5																				
1/14-13								1	3																	
1/14-14																										
1/14-15								3	3	6	10															
1/14-16								8	7	7	4	3	3	3	3	5										
1/14-17													1	3	3	3	6	8	8	8	4					
1/14-18												8	9	3	2	3	4	7	4	5	6					
1/14-19							12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	22	25	12	22	10
1/14-20										7	12	12	12	4	5	9	18	17	10	12	7	7	6	4	3	3
1/14-21										6	23	21														
1/14-22								12	23	21																
1/14-23										1	3	3	3	3												
1/15-13								2	5	4	5	6	5	9	6	6	3	4	5	5	5	5	6	9	3	3
1/15-14						5	5	4	5	6	8	6	6	5	4	4	5	5	5	5	10	4	3	3	5	6
1/15-23			2	3	3	3	3	3	26	13	5	15	25	25	19	23	15	12	12	12	12	12	12	12	12	12
1/15-24					4	6	5	5	6	5	4	2	3	16	8	5	10	15	17	12	15	10	4	5	5	5

ESTIMATED AVERAGE SPECIFIC YIELD VALUES[1] BY ELEVATIONAL INCREMENTS, COASTAL PLAIN OF LOS ANGELES COUNTY

LOS ANGELES FOREBAY AREA

(IN PERCENT)

LOCATION[2]	ELEVATIONAL INCREMENTS IN FEET ABOVE SEA LEVEL																									
	320 300	300 280	280 260	260 240	240 220	220 200	200 180	180 160	160 140	140 120	120 100	100 80	80 60	60 40	40 20	20 0	0 -20	-20 -40	-40 -60	-60 -80	-80 -100	-100 -120	-120 -140	-140 -160	-160 -180	-180 -200
1/12-31			8	23	23	8	3	12	10	4	3	3	3	3	5	5	5	5	5	5	5	6	7	7	7	7
1/13-21	3	4	8	8	8	8																				
1/13-22	3	3																								
1/13-23		6	18	7																						
1/13-26	8	9	9	5	5	5																				
1/13-27			11	16	15	13	9	10	10																	
1/13-28	13	13	15	15	10	14																				
1/13-29	15	21	13	17	23	13	3	3	3	3	3															
1/13-30				2	15	8	10	21	16	15	21															
1/13-31						4	18	8	12	12	15	19	21	18	3	4	11	4	13	8	13					
1/13-32					3	13	13	14	19	17	17	19	14	10	13	12	7	13	12	3	11					
1/13-33				2	5	10	14	14	14	14	15	18	3	3	3	3	3									
1/13-34				7	13	14	10	13	10	7	4	3	3	3	3	3										
1/13-35									6	6	6	6	6	6	6	6										
1/13-36								8	5	3	3	3	3	4	5	5	5	5	5							
1/14-13								1	3																	
1/14-14																										
1/14-20										7	12	12	12	4	5	9	18	17	10	12	7	7	6	3	3	3
1/14-21										6	23	21														
1/14-22								12	23	21																
1/14-23										1	3	3	3	3												
1/14-24									2	3	3	3	3	3												
1/14-25												3	3	3	3	3	3	3	3							
1/14-26													1	3	3	3	3	3	3	3	3					
1/14-36								5	23	23	11	3	9	12	4	3	3	3	3	6	7	7	7	7		
2/12-06						7	12	12	12	20	20	22	14	14	7	7	16	6	4	4	4	4	4	3	4	12
2/12-07									14	21	21	15	5	5	10	17	21	21	21	12	5	5	5	5	5	5
2/13-01					2	3	3	3	3	4	16	16	16	16	16	16	16	16	10	16	11	4	3	6	3	7
2/13-02										3	9	12	14	20	21	18	15	20	19	23	15	10	9	11	10	12
2/13-03					8	16	16	16	16	18	4	7	3	8	18	3	4	16	4	3	3	3	3	3	9	9
2/13-04					14	21	16	10	10	9	6	12	19	14	17	12	10	15	3	3	3	4	4	4	6	3
2/13-05					4	14	19	13	19	19	13	14	13	12	12	9	4	11	9	11	6	16	15	12	12	12
2/13-06							8	21	7	14	3	14	23	21	17	3	6	18	7	22	14	22	23	15	15	15
2/13-07								9	8	4	5	4	17	14	13	6	3	9	6	9	13	9	13	13	13	3
2/13-08							1	7	11	20	18	14	16	11	17	12	17	5	5	5	5	5	9	10	20	21

ESTIMATED AVERAGE SPECIFIC YIELD VALUES[1] BY ELEVATIONAL INCREMENTS, COASTAL PLAIN OF LOS ANGELES COUNTY

LOS ANGELES FOREBAY AREA (CONTINUED)

(IN PERCENT)

LOCATION[2]	ELEVATIONAL INCREMENTS IN FEET ABOVE SEA LEVEL																									
	320 300	300 280	280 260	260 240	240 220	220 200	200 180	180 160	160 140	140 120	120 100	100 80	80 60	60 40	40 20	20 0	0 -20	-20 -40	-40 -60	-60 -80	-80 -100	-100 -120	-120 -140	-140 -160	-160 -180	-180 -200
2/13-09						1	11	12	14	23	16	21	20	19	16	17	17	17	17	17	17	17	17	17	17	17
2/13-10					2	5	14	12	12	12	12	14	14	13	11	11	8	5	5	5	5	8	6	10	8	7
2/13-11						1	6	5	5	6	7	9	10	9	7	11	9	9	9	7	5	5	7	8	10	9
2/13-12									1	1	1	3	9	10	7	4	5	11	6	9	9	5	4	6	7	7
2/13-14							4	10	9	3	5	12	9	6	6	7	8	11	8	10	12	15	19	20	20	23
2/13-15							7	19	17	16	16	11	14	13	10	9	9	9	8	11	24	26	29	18	11	11
2/13-16								6	16	18	15	9	3	5	9	16	7	8	6	3	21	26	17	12	[illegible]	[illegible]
2/13-17								5	8	6	7	5	9	6	9	11	5	4	4	6	4	6	5	4	2	6
2/13-18														13	10	3	3	3	3	3	3	2	2	5	5	5
2/13-20								1	1	2	8	11	12	14	12	7	5	4	4	6	12	5	5	9	7	[illegible]
2/13-21								3	9	19	21	21	20	13	14	10	5	7	4	4	12	16	22	15	12	12
2/13-22								13	11	11	10	7	14	15	10	10	7	4	5	4	20	13	20	14	17	15
2/13-23											1	1	4	7	8	8	6	8	6	6	17	17	18	19	10	16
2/13-24												3	1	11	7	3	8	3	5	5	7	12	16	8	8	13
2/13-25													6	8	5	6	7	6	7	4	11	12	17	17	14	20
2/13-26													4	4	4	4	4	6	4	4	14	17	21	20	21	17
2/13-27												1	2	8	6	8	8	7	8	9	12	20	12	10	12	2
2/14-01									7	9	22	8	20	3	3	21	11	11	11	11	11	11	11	11	11	11
2/14-12									13	14	12	17	11	3	12	17	9	9	9	9	9	9	9	9	9	9
2/14-13											2	2	7	6	12	5	4	6	3	3	4	4	3	3	3	3

ESTIMATED AVERAGE SPECIFIC YIELD VALUES[1] BY ELEVATIONAL INCREMENTS, COASTAL PLAIN OF LOS ANGELES COUNTY

MONTEBELLO FOREBAY AREA

(IN PERCENT)

LOCATION[2]	ELEVATIONAL INCREMENTS IN FEET ABOVE SEA LEVEL																									
	320 300	300 280	280 260	260 240	240 220	220 200	200 180	180 160	160 140	140 120	120 100	100 80	80 60	60 40	40 20	20 0	0 -20	-20 -40	-40 -60	-60 -80	-80 -100	-100 -120	-120 -140	-140 -160	-160 -180	-180 -200
1/12-32				5	8	7	1	2	13	6	9	12	12	7	5	5	11	11	8	10	13	11	14	8	3	11
1/12-33										7	21	13	21	21	21	9	5	10	23	23	8					
1/12-34	3	13	8	3	9	13	9	13	13	13	4	5	10	14	14	4	12	14	14	13	9					
1/12-35	14	13	10	13	9	9	13	6	11	11	6	9	7	7	8	5	8	13	16							
2/11-06						9	23	23	14	10	12	26	26	26	26	11	15	16	16	16	14	11	16	16	16	16
2/11-07			1	7	7		5	14	18	18	15	16	18	20	13	12	16	13	15	16	8	7	10	10	6	7
2/11-08					1	3	5	7	6	2	3	7	3	5	19	4	4	3	3	12	5	5	5	6	5	5
2/11-17				4	2	3	8	2	3	7	6	11	8	4	3	4	6	6	4	9	8	8	5	4	4	4
2/11-18								10	15	15	14	12	8	9	12	11	13	13	12	10	8	6	10	12	14	11
2/11-19								4	14	9	15	19	16	9	7	8	7	8	12	13	15	17	12	5	7	15
2/11-30									4	8	13	13	13	15	12	15	10	10	11	7	4	13	15	20	14	16
2/11-31										6	13	16	16	14	12	11	4	4	3	3	3	7	14	3	5	3
2/12-01							1	6	10	10	6	11	8	10	14	9	13	12	12	13	10	6	12	8	12	8
2/12-02	8	11	6	13	14	5	13	10	5	6	4	6	10	13	15	15										
2/12-03							13	26	9	5	5	5	5	5	5	3	4	5	5	5	5					
2/12-04								3	5	5	4	3	3	3	4	5	5	5	5	5	5	5	9	3	3	3
2/12-05															2	7	16	5	5	5	5	5	5	11	18	5
2/12-09														18	5	5	13	13	3	3	15	17	26	25	7	5
2/12-10							1	5	7	16	7	9	5	9	9	8	5	4	12	14	12	17	9	4	4	8
2/12-11								4	15	15	21	5	5	5	16	10	8	7	4	17	21	5	21	16	3	3
2/12-12							4	20	20	20	14	8	7	17	6	12	15	13	19	19	21	21	13	7	14	14
2/12-13							1	7	17	19	19	16	17	14	9	11	19	14	9	11	9	13	18	14	13	13
2/12-14							10	17	17	19	13	13	10	10	15	15	10	4	8	10	11	19	18	15	5	4
2/12-15										4	5	5	5	5	5	5	5	5	5	15	16	14	3	5	12	14
2/12-16										1	5	5	5	5	5	5	5	5	5	7	16	16	10	3	5	15
2/12-21											3	6	4	5	3	10	7	6	6	4	8	12	12	12	12	14
2/12-22								7	21	18	18	17	9	6	8	17	14	17	9	4	3	6	11	11	12	14
2/12-23								1	15	15	16	14	14	14	6	13	16	16	7	3	3	3	10	10	10	10
2/12-24									17	20	17	18	17	13	11	9	11	12	10	6	8	7	16	15	15	14
2/12-25									7	12	10	13	13	15	10	9	5	4	6	10	14	19	8	14	13	9
2/12-26												20	21	17	13	4	9	3	3	3	3	6	21	21	14	11
2/12-27									1	8	11	18	15	9	8	6	16	13	15	17	14	13	10	9	7	9
2/12-28										2	1	8	10	10	8	11	6	13	13	10	4	6	17	16	10	6
2/12-33											2	9	18	14	7	11	9	5	5	4	5	5	7	9	4	4
2/12-34											2	8	14	17	16	10	12	9	11	11	9	7	7	7	5	10

ESTIMATED AVERAGE SPECIFIC YIELD VALUES[1] BY ELEVATIONAL INCREMENTS, COASTAL PLAIN OF LOS ANGELES COUNTY

MONTEBELLO FOREBAY AREA (CONTINUED)

(IN PERCENT)

LOCATION[2]	ELEVATIONAL INCREMENTS IN FEET ABOVE SEA LEVEL																									
	320 300	300 280	280 260	260 240	240 220	220 200	200 180	180 160	160 140	140 120	120 100	100 80	80 60	60 40	40 20	20 0	0 -20	-20 -40	-40 -60	-60 -80	-80 -100	-100 -120	-120 -140	-140 -160	-160 -180	-180 -200
2/12-35											2	7	19	15	11	16	9	14	12	8	6	8	13	11	15	12
2/12-36										5	23	22	5	3	13	5	5	5	4	5	7	21	15	14	14	5
3/11-06											2	7	10	16	16	14	9	7	7	8	7	4	5	5	4	5
3/12-01										1	2	9	15	15	16	13	13	12	13	13	11	16	14	14	9	12
3/12-02													5	13	18	20	12	12	12	11	9	8	7	8	10	8
3/12-03													3	8	19	12	20	11	5	10	6	7	12	10	10	17
3/12-11													1	11	16	14	16	10	5	3	5	15	12	9	7	12
3/12-12											1	4	10	16	15	10	10	12	8	12	11	11	8	11	5	13

(Continued)

ESTIMATED AVERAGE SPECIFIC YIELD VALUES[1] BY ELEVATIONAL INCREMENTS, COASTAL PLAIN OF LOS ANGELES COUNTY

WHITTIER AREA

(IN PERCENT)

LOCATION[2]	ELEVATIONAL INCREMENTS IN FEET ABOVE SEA LEVEL																									
	320 300	300 280	280 260	260 240	240 220	220 200	200 180	180 160	160 140	140 120	120 100	100 80	80 60	60 40	40 20	20 0	0 -20	-20 -40	-40 -60	-60 -80	-80 -100	-100 -120	-120 -140	-140 -160	-160 -180	-180 -200
2/10-31					1	5	5	5	4	3	3	5	5	3	3	5	21	5	4	17	10	8	5	9	9	5
2/11-16		7	8	4	12	4	4	3	7	7	4	4	6	6	4	3										
2/11-20											4	6	10	3	3	4	4	6	8	4	3	3	9	3	3	3
2/11-21					4	6	10	3	3	4	4	6	8	4	3	3	9	3	3	3	3	6	3	3	3	4
2/11-26						2	4	4	4	3	3	3	3	5	7	3	3	4	3	3	3	9	14	14	15	10
2/11-27	6	2	2	3	2	2	2	2	8	5	4	4	3	3	4	4	5	5	4	4	4	3	3	3	9	9
2/11-28					2	6	10	11	5	4	3	3	5	12	7	4	5	4	3	4	5	5	5	5	4	3
2/11-29											15	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17
2/11-32									2	3	15	10	13	9	5	4	7	10	9	6	4	4	4	4	4	4
2/11-33											12	6	3	5	5	3	3	4	5	15	4	4	5	3	3	5
2/11-34					2	6	2	2	3	2	2	2	2	8	5	4	4	3	3	4	4	5	5	4	4	4
2/11-35														5	4	4	3	3	3	3	4	7	3	3	3	4
2/11-36	3	3	3	5	7	5	4	4	4	4	3	4	4	13	13	13										
3/10-06							2	5	5	5	3	3	4	5	4	3	3	8	18	4	7	15	9	7	5	12
3/10-07													1	3	3	18	21	22	17	4	14	23	19	13	6	13
3/11-01				2	1	7	8	6	3	3	3	5	5	7	5	4	4	5	5	3	3	4	20	11	10	18
3/11-02																2	3	3	3	3	5	5	3	4	3	3
3/11-03										1	3	2	2	2	2	2	6	2	4	4	3	6	11	6	10	5
3/11-04											7	15	3	8	9	11	3	12	3	4	5	3	8	17	7	16
3/11-05										3	9	6	10	7	3	4	6	6	6	6	3	3	6	13	7	17
3/11-10								6	3	2	4	4	4	4	4	3	3	3	4	3	4	3	4	3	4	5
3/11-11																5	4	5	10	9	11	6	4	11	10	9
3/11-12												2	3	6	23	18	24	10	4	21	22	16	8	13	13	13
3/11-13															3	5	3	11	23	8	5					

(Continued)

ESTIMATED AVERAGE SPECIFIC YIELD VALUES[1] BY ELEVATIONAL INCREMENTS, COASTAL PLAIN OF LOS ANGELES COUNTY

CENTRAL BASIN PRESSURE AREA

(IN PERCENT)

LOCATION[2]	ELEVATIONAL INCREMENTS IN FEET ABOVE SEA LEVEL																									
	320 300	300 280	280 260	260 240	240 220	220 200	200 180	180 160	160 140	140 120	120 100	100 80	80 60	60 40	40 20	20 0	0 -20	-20 -40	-40 -60	-60 -80	-80 -100	-100 -120	-120 -140	-140 -160	-160 -180	-180 -200
1/14-19							12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	22	25	19	23	19
1/14-27										3	12	11	13	3	3	3	3	3	3							
1/14-28										6	11	11	9	2	9	5	3	9	4	6	6					
1/14-29															4	6	8	12	18	6	12	15	10	12	12	6
1/14-30											23	14	14	14	14	10	9	9	9	9	9	9	9	9	9	9
1/14-31											9	21	19	19	19	16	13	5	21	23	23	23	24	26	26	26
1/14-32													2	13	16	9	10	12	11	4	8	12	15	15	15	17
1/14-33													9	12	16	20	15	22	12	8	21	22	19	13	14	15
1/14-34									8	21	21	10	5	3	3	15	3	3	4	3	3	19	21	21	21	21
1/14-35							1	19	5	21	18	7	23	23	22	5	16	16	18	13	5	5	4	3	8	5
1/15-24					4	6	5	5	6	5	4	2	3	16	8	5	10	15	17	12	15	10	4	5	5	5
1/15-25					12	19	14	14	14	12	10	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12
2/12-08										1	1	1	1	10	5	4	4	4	7	4	6	5	5	6	6	7
2/12-17										3	11	11	12	19	16	13	12	15	12	12	4	4	4	12	6	4
2/12-18										7	11	14	14	13	9	9	15	18	19	15	19	14	9	9	5	5
2/12-19															4	6	11	9	8	5	8	9	11	13	18	19
2/12-20																2	9	3	5	5	8	8	8	12	19	19
2/12-29													5	2	4	5	7	9	10	6	5	5	9	10	11	11
2/12-30															1	10	5	7	15	6	12	12	16	15	10	12
2/12-31																	4	9	7	7	14	12	15	13	11	6
2/12-32													10	5	6	16	11	13	10	5	8	5	5	10	6	4
2/13-13												3	4	3	2	7	12	8	6	6	9	9	11	7	7	9
2/13-19												3	9	6	14	5	17	9	9	9	9	9	9	9	9	9
2/13-28									3	11	10	9	12	18	18	22	22	8	3	3	12	4	5	5	9	9
2/13-29										5	5	2	9	11	10	10	9	5	3	3	3	6	3	3	5	
2/13-30											2	10	9	7	9	6	11	3	10	11	13	3	3	6	16	23
2/13-31											1	4	4	2	2	2	2	5	12	10	9	4	4	4	8	10
2/13-32												3	6	2	2	2	4	2	5	3	3	5	4	5	7	10
2/13-33													2	8	8	8	4	5	4	3	3	10	4	4	5	6
2/13-34												5	5	10	16	16	14	16	5	3	3	8	14	6	4	4
2/13-35															5	12	10	10	3	3	20	12	12	12	11	7
2/13-36														1	9	2	7	10	4	15	14	21	16	24	22	22
2/14-02									13	11	15	23	4	21	23	23	10	13	16	18	16	5	5	5	3	5
2/14-03												2	11	18	13	4	6	3	5	8	5	8	5	6	15	15
2/14-04													7	16	15	13	12	12	10	4	12	11	8	3	3	3

(Continued)

ESTIMATED AVERAGE SPECIFIC YIELD VALUES[1] BY ELEVATIONAL INCREMENTS, COASTAL PLAIN OF LOS ANGELES COUNTY

CENTRAL BASIN PRESSURE AREA (CONTINUED)

(IN PERCENT)

LOCATION[2]	ELEVATIONAL INCREMENTS IN FEET ABOVE SEA LEVEL																									
	320 300	300 280	280 260	260 240	240 220	220 200	200 180	180 160	160 140	140 120	120 100	100 80	80 60	60 40	40 20	20 0	0 -20	-20 -40	-40 -60	-60 -80	-80 -100	-100 -120	-120 -140	-140 -160	-160 -180	-180 -200
2/14-05											2	2	3	12	10	9	8	8	9	8	11	11	13	15	12	9
2/14-06														20	17	9	5	5	5	5	5					
2/14-08														3	5	5	5	5	5	5	5					
2/14-09			2	6	10	5	12	7	4	11	12	14	3	3	3	4	4	3	22	17	23	5	3	3	3	3
2/14-10												5	9	4	4	4	4	3	4	3	5	15	7	6	4	10
2/14-11											3	7	6	10	5	8	10	10	6	5	11	8	8	5	4	4
2/14-14												5	8	9	6	4	5	4	5	4	5	4	6	6	3	8
2/14-15														1	22	5	5	5	11	7	3	14	13	21	17	17
2/14-16				2	2	3	2	12	17	13	9	11	15	3	11	6	13	10	13	9	3					
2/14-21									5	4	5	6	10	17	18	13	17	8	10	16	13	5	5	3	10	10
2/14-22										1	4	11	15	15	16	15	13	11	12	3	6	13	10	6	4	5
2/14-23												1	4	6	7	7	7	9	7	7	4	4	6	12	17	12
2/14-24												2	12	9	18	4	5	13	4	4	4	7	7	7	7	7
2/14-25											17	14	5	21	12	12	12	12	12	12	12	12	12	12	12	12
2/14-26								2	8	3	7	6	3	4	4	6	3	4	4	5	13	8	10	6	10	10
2/14-27								1	3	6	8	13	14	11	12	12	10	11	11	11	10	11	11	9	8	7
2/14-34											2	9	18	19	15	15	11	8	8	8	8	15	18	20	19	14
2/14-35										9	11	11	19	16	16	15	12	13	20	19	20	21	19	19	16	12
2/14-36									1	10	6	4	7	3	8	8	16	15	16	12	8	9	9	13	13	11
3/11-07												4	14	20	12	12	13	12	19	6	6	8	11	9	6	6
3/11-08											3	8	11	10	15	21	18	16	7	12	12	12	12	12	12	12
3/11-09											7	5	4	5	4	5	5	4	4	3	3	4	4	4	3	3
3/11-14														2	4	9	10	12	9	10	14	9	14	13	10	10
3/11-15													4	5	4	3	3	3	3	3	3	3	3	3	4	3
3/11-16												4	9	9	11	6	10	9	8	9	23	18	12	16	18	19
3/11-17												3	1	3	5	8	12	8	7	6	13	14	13	13	11	13
3/11-18													5	5	4	8	10	8	9	12	15	15	20	20	13	13
3/11-19																2	6	12	9	7	11	12	9	9	9	8
3/11-20															1	2	6	10	9	9	11	10	11	7	9	9
3/11-21														1		1	4	11	7	11	11	12	11	10	10	10
3/11-22																			2	4	6	8	8	8	8	10
3/11-23											9	2	2	2	8	9	9	9	8	8	11	11	9	10	8	8
3/11-24									1	1	1	1	2	8	4	5	4	6	4	8	5	3	4	10	8	4
3/11-26															2	1	4	4	4	4	6	4	3	3	4	4
3/11-27																3	5	6	6	11	14	10	7	7	7	11

(Continued)

ESTIMATED AVERAGE SPECIFIC YIELD VALUES[1] BY ELEVATIONAL INCREMENTS, COASTAL PLAIN OF LOS ANGELES COUNTY

CENTRAL BASIN PRESSURE AREA (CONTINUED)

(IN PERCENT)

LOCATION[2]	ELEVATIONAL INCREMENTS IN FEET ABOVE SEA LEVEL																									
	320 300	300 280	280 260	260 240	240 220	220 200	200 180	180 160	160 140	140 120	120 100	100 80	80 60	60 40	40 20	20 0	0 -20	-20 -40	-40 -60	-60 -80	-80 -100	-100 -120	-120 -140	-140 -160	-160 -180	-180 -200
3/11-28													1	1			3	9	8	6	13	19	31	16	8	10
3/11-29																	2	8	8	8	15	15	15	17	11	13
3/11-30																		7	9	8	22	22	22	22	23	22
3/11-31																		2	4	4	17	20	19	11	11	10
3/11-32																			2	3	6	8	11	10	7	12
3/11-33																			6	5	6	10	4	5	8	6
3/12-04											2	3	4	10	20	20	19	14	10	13	11	11	11	11	10	10
3/12-05														1	4	12	20	15	11	14	6	10	14	9	4	6
3/12-06															1	4	10	11	9	10	16	15	12	12	11	12
3/12-07															1	3	8	16	19	17	27	27	22	33	38	38
3/12-08																	8	19	20	20	15	8	10	7	4	4
3/12-09															9	15	19	18	13	6	3	4	8	10	10	7
3/12-10														7	18	21	19	13	12	4	5	4	3	3	3	3
3/12-13														8	14	15	13	8	9	8	20	9	6	7	10	8
3/12-14															8	16	16	9	4	5	6	6	4	4	4	5
3/12-15															11	17	18	18	12	10	12	12	12	12	12	12
3/12-16															1	5	12	15	16	16	23	11	9	4	4	5
3/12-17																		4	11	12	16	14	12	20	21	20
3/12-18																3	7	15	15	16	21	20	19	18	24	21
3/12-19																	1	11	16	17	21	14	14	16	16	17
3/12-20																			2	18	23	15	13	15	11	15
3/12-21																		1	5	11	22	12	16	24	24	21
3/12-22																		5	[illegible]	9	22	14	17	24	18	15
3/12-23																	3	11	14	16	17	12	12	12	12	12
3/12-24															2	3	6	17	19	17	19	24	18	17	17	14
3/12-25																	1	3	10	15	26	19	12	15	15	19
3/12-26													1	2	2	2	4	8	11	10	18	17	13	16	20	14
3/12-27																		3	4	7	11	17	16	13	9	12
3/12-28																				6	19	11	8	11	8	8
3/12-29																			2	9	21	23	11	19	15	20
3/12-30															1	2	11	15	13	16	16	4	3	7	5	3
3/12-31																6	11	2	12	3	3	7	12	4	23	23
3/12-32													1	12	12	12	12	12	12	12	24	12	12	12	12	12
3/12-33																			4	3	10	14	11	13	12	16
3/12-34																		3	4	5	12	15	12	14	13	10

(Continued)

ESTIMATED AVERAGE SPECIFIC YIELD VALUES[1] BY ELEVATIONAL INCREMENTS, COASTAL PLAIN OF LOS ANGELES COUNTY

CENTRAL BASIN PRESSURE AREA (CONTINUED)

(IN PERCENT)

LOCATION[2]	ELEVATIONAL INCREMENTS IN FEET ABOVE SEA LEVEL																									
	320 300	300 280	280 260	260 240	240 220	220 200	200 180	180 160	160 140	140 120	120 100	100 80	80 60	60 40	40 20	20 0	0 -20	-20 -40	-40 -60	-60 -80	-80 -100	-100 -120	-120 -140	-140 -160	-160 -180	-180 -200
3/12-35													1		1	2	2	5	11	12	8	12	14	16	9	7
3/12-36																	3	6	8	10	8	20	16	25	10	11
3/13-01																		8	6	9	14	14	14	14	14	29
3/13-02																3	13	16	17	14	5	7	9	13	19	10
3/13-03														1	11	8	5	5	5	5	5	5	3	3	3	4
3/13-04														2	3	8	11	4	3	3	6	7	3	3	6	11
3/13-05												7	4	3	4	6	4	4	9	3	3	3	4	8	13	5
3/13-06										4	8	8	8	15	17	13	10	23	17	19	17	19	19	23	23	9
3/13-07											2	12	16	17	17	16	17	22	20	21	20	17	14	13	16	16
3/13-08																4	7	7	8	9	10	12	11	9	10	12
3/13-09															5	2	5	4	3	3	3	3	7	14	8	13
3/13-10														7	10	9	3	4	4	4	4	4	10	12	9	11
3/13-11															2	8	17	15	7	7	7	6	6	6	6	5
3/13-12																2	9	12	11	13	4	7	6	4	6	6
3/13-13																	13	17	14	7	14	6	4	4	4	7
3/13-14																	9	22	17	17	17	17	17	17	17	17
3/13-15															1	4	6	4	5	4	7	7	4	12	16	12
3/13-16														2	2	5	3	6	12	10	13	17	13	9	5	5
3/13-17												1			1	6	10	8	11	8	10	12	13	9	11	15
3/13-18													1	1	2	5	4	4	9	8	11	9	14	13	15	18
3/13-20															1	1	7	18	17	15	11	8	17	10	9	6
3/13-21												1	5	8	4	5	13	20	19	13	11	18	14	5	7	12
3/13-22																1	4	5	11	9	7	8	8	15	19	19
3/13-23													1	3	3	4	7	13	14	10	9	10	14	16	19	15
3/13-24																2	8	16	18	16	24	12	12	12	12	12
3/13-25																3	11	19	16	14	10	4	4	3	3	3
3/13-26																	4	13	10	10	6	8	3	7	4	8
3/13-27																9	8	11	12	9	9	13	14	11	12	14
3/13-28												4	5	5	6	6										
3/13-29																1	1	5	8	7	10	11	15	9	14	10
3/13-33													9	15	16	16	14	16	15	16	17	12	11	15	4	4
3/13-34													1	5	13	17	7	8	10	9	10	16	9	14	17	18
3/13-35																	7	19	18	12	6	8	6	7	7	8
3/13-36																	5	14	12	9	4	4	4	3	4	5
3/14-01											2	11	12	13	14	14	16	19	19	19	18					

(Continued)

ESTIMATED AVERAGE SPECIFIC YIELD VALUES[1] BY ELEVATIONAL INCREMENTS
COASTAL PLAIN OF LOS ANGELES COUNTY
CENTRAL BASIN PRESSURE AREA (CONTINUED)
(IN PERCENT)

LOCATION[2]	ELEVATIONAL INCREMENTS IN FEET ABOVE SEA LEVEL																									
	320 300	300 280	280 260	260 240	240 220	220 200	200 180	180 160	160 140	140 12C	120 100	100 80	80 60	60 40	40 20	20 0	0 -20	-20 -40	-40 -60	-60 -80	-80 -100	-100 -120	-120 -140	-140 -160	-160 -180	-180 -200
3/14-02											1	7	6	8	9	12	9	12	8	9	12	9	9	11	8	8
3/14-12										1	4	9	15	16	15	14	17	21	16	15	15	8	9	11	15	12
4/11-05																		1	2	2	9	11	13	7	7	14
4/11-06																	1	5	4	4	10	13	16	16	9	9
4/11-07																			1	2	8	8	8	9	11	17
4/11-08																			1	2	8	9	10	12	5	16
4/11-18																				2	16	18	29	37	36	30
4/11-19																	2	2	4	12	28	8	5	3	5	4
4/12-01																		1	6	7	13	17	17	17	17	11
4/12-02														1	2	1	1	1	1	3	12	15	15	19	14	10
4/12-03																		6	9	5	12	12	17	13	13	12
4/12-04														8	5	4	10	3	3	3	12	12	20	12	12	26
4/12-05																				3	12	12	12	17	8	7
4/12-06																				3	17	8	4	9	12	16
4/12-07																					28	20	28	30	30	11
4/12-08																			3	5	14	16	20	11	14	19
4/12-09																					7	11	21	22	26	10
4/12-10																	5	9	3	3	10	12	11	11	11	11
4/12-11																					23	16	16	19	34	22
4/12-12																		2	3	1	9	10	12	13	16	27
4/12-13															1	3	3	7	12	10	16	19	19	21	16	20
4/12-14																2	8	5	6	6	17	16	16	16	15	17
4/12-15															1	2	7	4	3	6	18	8	20	10	10	14
4/12-16																1	2	2	6	3	12	16	19	15	19	14
4/12-17																		3	6	8	22	21	19	21	22	24
4/12-18																1	23	23	23	16	27	16	16	17	10	4
4/12-19													1	1	2	5	11	18	15	11	11	14	13	14	16	14
4/12-20															1	3	4	7	11	7	8	11	11	8	8	8
4/12-21															2	3	5	6	9	13	9	11	10	12	12	12
4/12-22																8	8	8	8	8	16	16	16	16	8	8
4/12-23																	8	20	11	5	7	10	17	19	9	9
4/12-24																	1	8	9	6	19	18	16	17	16	20
4/12-25																		1	2	10	17	13	13	13	13	14
4/12-26																			2	8	20	18	14	19	19	23
4/12-27																	3	10	20	21	39	30	26	32	16	15

(Continued)

ESTIMATED AVERAGE SPECIFIC YIELD VALUES[1] BY ELEVATIONAL INCREMENTS, COASTAL PLAIN OF LOS ANGELES COUNTY

CENTRAL BASIN PRESSURE AREA (CONTINUED)

(IN PERCENT)

LOCATION[2]	ELEVATIONAL INCREMENTS IN FEET ABOVE SEA LEVEL																									
	320 300	300 280	280 260	260 240	240 220	220 200	200 180	180 160	160 140	140 120	120 100	100 80	80 60	60 40	40 20	20 0	0 -20	-20 -40	-40 -60	-60 -80	-80 -100	-100 -120	-120 -140	-140 -160	-160 -180	-180 -200
4/12-28																			2	9	14	16	20	19	20	17
4/12-29																				2	5	5	5	10	3	3
4/12-33																							7	9	10	12
4/12-34																	1	10	15	16	15	10	12	7	10	15
4/12-35																					3	12	14	14	13	17
4/12-36																			5	1	3	9	8	4	3	6
4/13-01																1	4	3	4	10	6	5	7	13	10	10
4/13-02														1	3	5	13	19	20	17	9	9	10	4	9	12
4/13-03																			3	16	18	16	9	3	3	3
4/13-11																	2	13	14	17	8	10	9	9	9	9
4/13-12														5	2	2	6	12	15	15	16	7	7	7	7	14
4/13-13																			2	10	4	3	12	9	15	22
4/13-24																			5	14	15	8	18	8	9	6
5/12-01																			14	3	3	3	3	3	3	3
5/12-02																	1	5	16	15	11	10	7	6	6	7
5/12-11																2	5	11	15	11	25	10	10	9	9	10

Footnotes:

1. Where no value is shown specific yield was assumed to be zero or the elevational increment was above the ground surface or below the base of the deepest aquifer. For this tabulation all the deposits above the base of the Bellflower Aquiclude were considered to have zero specific yield. Also the tabulation was limited to the elevations between + 320 and -200 feet because it is within this range that change in ground water storage occurs.
2. Location is referenced to the U. S. Public Land Survey as projected into the Coastal Plain of Los Angeles County. 1/14 - 30 refers to Township 1 South, Range 14W, Section 30, San Bernardino Base and Meridian. The estimated average specific yield values given refer to the section or portion of a section lying within the boundary of the specified ground water basin.

TRANSMISSIBILITY TEST PROCEDURES

The transmissibility rates of aquifers penetrated by wells in the Coastal Plain of Los Angeles County were determined by the use of drawdown and recovery tests, in addition to other available data. A drawdown test is one in which measurements of the ground water levels are taken starting the moment the well is turned on and continued as long as possible or until the water level stabilizes or draws down very slowly. The measurements are usually taken in an observation well perforated in the same aquifer as the pumping well, but the measurements may be taken in the pumping well. The quantity of ground water pumped is also measured.

A recovery test is essentially the reverse of a drawdown test. A well is pumped for a known amount of time and the discharge measured. Starting at the time the pump is shut off, ground water levels are measured at frequent intervals. The measurements are continued until the static level is approximately reached (the static water level is where the water level in the well would stand if not affected by pumping in the well or in nearby wells). The water level measurements are made in the pumping well, or in a nearby observation well perforated in the same aquifer as the pumping well.

In both tests, the change in water level can be plotted against the time required for the change. Using formulas previously determined, the transmissibility, horizontal permeability, storage coefficient, and vertical permeability can be computed when a pumping and observation well are used together. When a test is run in the pumping well, generally only transmissibility and horizontal permeability can be determined.

The transmissibility rate, or the coefficient of transmissibility, is the flow of water, in gallons per day at the prevailing water temperature, through a vertical strip of the aquifer one foot wide having a height equal to the thickness of the aquifer and under a unit hydraulic gradient. It has also been described at "the field coefficient of permeability" multiplied by the thickness, in feet, of the saturated part of the aquifer.

The permeability of a material is its capacity for transmitting a fluid. The coefficient of permeability is the rate of flow of water in gallons a day through a cross section of one square foot under a unit hydraulic gradient. The standard coefficient is defined for water at a temperature of 60°F. The field coefficient requires no temperature adjustment and the units are stated in terms of the prevailing water temperature.

The horizontal permeability refers to the flow of water into a pumping well from an aquifer penetrated by the well.

Vertical permeability as used in this attachment refers to the movement of water through a confining bed into the underlying aquifer.

The leakage coefficient is used to describe the numerical quantity derived by dividing the vertical permeability of a confining bed by the thickness in feet through which this leakage occurs.

Storage coefficient, or the coefficient of storage, is the volume of water in cubic feet released from storage in each vertical column of water having a base one foot square when the water table or piezometric surface declines one foot. It is expressed as a decimal figure with no units.

An aquifer is a geologic formation, group of formations, or part of a formation that transmits water in sufficient quantity to supply pumping wells or springs.

TABLE C

TRANSMISSIBILITY TESTS IN THE
COASTAL PLAIN OF LOS ANGELES COUNTY

Observation well(s)	Pumping well(s)	Date of test	Type of test	Aquifer(s)	Transmissibility gal./day/ft.	Estimated horizontal permeability gal./day/sq.ft.	Storage coefficient	Leakage coefficient gal./day/ft.	Estimated vertical permeability gal./day/sq.ft.
	2S/11W- 7J2	4- 5-57	Recovery	Pleistocene and Recent	130,000	575			
	2S/11W- 8N1	4- 5-57	Recovery	Pleistocene and Recent	53,000	246			
2S/11W-18K2	2S/11W-18Q4	8-12-59	Drawdown	Recent and Lower Pleistocene	410,000	2,830	$1.7X10^{-3}$		
2S/11W-18P2	2S/11W-18Q2	2-24-59	Drawdown	Lower Pleistocene	690,000	3,300	$2.3X10^{-3}$		
2S/11W-18Q4	2S/11W-18Q2	2-24-59	Drawdown	Lower Pleistocene	190,000	1,195	$2.9X10^{-4}$		
2S/14W-19C1	2S/14W-19C2	6-26-50	Drawdown	Lower Pleistocene	170,000	600	$2.9X10^{-3}$	$1.2X10^{-7}$	$1.2X10^{-6}$
	2S/14W-27J1	7- 7-50	Recovery	Silverado	92,500	1,050			
2S/15W-34A3	2S/15W-34A1	6- 2-49	Recovery	Gardena and Lynwood	82,600	1,173	$4.2X10^{-5}$	$1.9X10^{-8}$	$1.2X10^{-6}$
	3S/11W-23P2	12-10-59	Recovery	Lynwood	2,410	160			
	3S/11W-26B5	12-11-59	Recovery	Silverado	21,000	420			
	3S/11W-27G1	12-21-59	Recovery	Silverado	11,000	212			
	3S/11W-27G3	12-22-59	Recovery	Lynwood	19,000	247			
	3S/12W-23C3	10-20-60	Recovery		34,254	952			
	3S/13W- 8R1	1-26-50	Recovery	Lynwood and Silverado	43,000	580			
	3S/13W-17A1	6-30-50	Recovery	Gardena and Silverado	110,000	1,908			
3S/13W-20H1 -20H3	3S/13W-20H7	12- -49 6- -50	Drawdown Recovery	Gardena	380,000	5,310	$1.6X10^{-2}$	$2.3X10^{-7}$	$3.7X10^{-6}$

TRANSMISSIBILITY TESTS IN THE
COASTAL PLAIN OF LOS ANGELES COUNTY
(continued)

Observation well(s)	Pumping well(s)	Date of test	Type of test	Aquifer(s)	Transmissibility: gal./day/ft.	Estimated horizontal permeability gal./day/sq.ft.	Storage coefficient	Leakage coefficient gal./day/ft.	Estimated vertical permeability gal./day/sq.ft.
	3S/13W-27E2	2- 2-50	Recovery	Silverado	126,000	3,730			
	3S/13W-28E2	6-22-50	Recovery	Lynwood and San Pedro	13,600	55			
3S/13W-29G6	3S/13W-29G3	1-30-58	Drawdown Recovery	Gardena	56,100	764	$9.0X10^{-4}$		
	3S/14W- 1G1	1-30-50	Recovery	Silverado	155,000	1,325			
3S/14W- 2D1	3S/14W- 3A1	6-27-50	Drawdown	Silverado	52,100	291	$1.03X10^{-4}$		
3S/14W- 4N1 - 4N2	3S/14W- 4N3	3-17-50	Drawdown	Lynwood and Silverado	220,000	934	$5.3X10^{-4}$		
3S/14W- 7Q2 - K2	3S/14W- 7Q3	3-17-50	Drawdown Recovery	Silverado	110,000	1,358	$2.5X10^{-4}$		
3S/14W-11G1	3S/14W-11C1	1-20-58	Drawdown	Lynwood, San Pedro Silverado	202,000	1,141	$2.95X10^{-3}$	$3X10^{-3}$	$1.51X10^{-6}$
3S/14W-10G1	3S/14W-10G2	4- 5-50	Drawdown	Lynwood and Silverado	153,000	735	$6.7X10^{-4}$		
	3S/14W-11J2	1- 2-58 1- 3-58	Recovery	Gage	157,000	1,743			
	3S/14W-25P4	12- 7-49	Recovery		422,000	4,350			
3S/15W-13H1 -13R1 -13R2	3S/15W-13A4	9-22-49	Drawdown Recovery	Lynwood and Silverado	103,000	495	$3.7X10^{-4}$	$5.3X10^{-9}$	$1.6X10^{-8}$
	4S/11W- 4R3	12- 8-59	Recovery	Artesia	30,000	1,500			
	4S/11W- 8J1	12-12-59	Recovery	Artesia	36,000	1,100			
	4S/11W-17H1	11-19-59	Recovery	Gage	4,700	362			
	4S/11W-17L2	11- 6-59	Recovery	Gage	31,000	1,008			

TRANSMISSIBILITY TESTS IN THE
COASTAL PLAIN OF LOS ANGELES COUNTY
(continued)

Observation well(s)	Pumping well(s)	Date of test	Type of test	Aquifer(s)	Transmissibility gal./day/ft.	Estimated horizontal permeability gal./day/sq.ft.	Storage coefficient	Leakage coefficient gal./day/ft.	Estimated vertical permeability gal./day/sq.ft.
	4S/11W-20M1	11-24-60	Recovery	Lynwood	60,000	1,052			
4S/13W- 2J1	4S/13W- 2R2	7-19-49	Drawdown	Gaspur, Gardena Lynwood	177,000	2,602	$8.1X10^{-4}$	$1.1X10^{-8}$	$3.3X10^{-7}$
	4S/13W- 7H1	6-28-50	Recovery	Silverado	280,000	1,657			
	4S/13W-12A1	7- 6-50	Recovery	Plio-Pleistocene	79,500	530			
4S/13W-15C1	4S/13W-15B8	2- -50	Drawdown	Silverado	821,000	3,258	$5.47X10^{-5}$	$1X10^{-8}$	$3.8X10^{-7}$
4S/13W-15C1	4S/13W-15P3	6-20-50	Drawdown		326,000	1,294			
4S/13W-27M1	4S/13W-27N1	10-19-49	Drawdown	Silverado	750,000	1,404	$1.9X10^{-3}$	$3.2X10^{-8}$	$4.6X10^{-6}$
	4S/13W-27N1	10-20-49	Recovery	Silverado	650,000	2,070			
	4S/14W- 8F1	8-24-49	Recovery		775,000	2,250			
	4S/14W-17H1	3-28-50	Recovery	Gardena, Lynwood, Silverado	680,000	2,464			

Assignment of Transmissibility Rates to Aquifer

The transmissibility rates for each aquifer and overall transmissibility rates for the coastal plain that were presented in this report were computed in the following manner:

1. All well logs used in the investigation were classified as to the aquifers intercepted and to the thickness of each aquifer at that well.

2. Permeability values of sediments were obtained from the transmissibility tests previously discussed. The results of these tests, summarized on Table C, were used as a basis for assigning representative values to the various materials encountered in the sediments. This simplification was necessary to reduce the amount of time that would otherwise have been necessary to evaluate each well log separately. The representative values of permeability used in the study are tabulated in Table D, following.

3. Using the values in Table D, a tabulation for each well log was completed that listed the materials encountered, the thickness of the material, and the permeability values used. By multiplying the thickness of each material by its permeability value, and adding together these products for the various materials found in each aquifer, the transmissibility rates of individual aquifers were computed for each well location.

4. The transmissibility values for each aquifer were plotted on maps of the coastal plain that also delineated lines of equal thickness of the particular aquifer in order to correlate the two. Contour lines of equal transmissibility rates were then drawn and interpolated and extrapolated into areas with only sparse data control. These contour lines are shown on Plates 26A to 26H for each aquifer.

5. Transmissibility rates at the northeast corner of each section for each aquifer were taken off the maps and tabulated. The values for each aquifer at each section corner were totaled, obtaining an overall transmissibility rate for that location. These overall rates were also plotted on a map and contours drawn representing lines of equal total transmissibility rates. This map of generalized lines of total transmissibility is presented as Plate 26I.

TABLE D

PERMEABILITY VALUES

ASSIGNED TO DRILLERS LOGS

Sandy Clay . . . . (includes gravelly clay, clay and sand, clayey sand, etc.)	50gpd/ft^2
Sand	500gpd/ft^2
Gravel (includes sand and gravel).	
Gaspur Aquifer	4000gpd/ft^2
Ballona Aquifer	2000gpd/ft^2
Marine Gravels (Silverado, Sunnyside, and portion of Lynwood aquifers).	1500gpd/ft^2
Nonmarine Gravels (Gardena, Artesia, Exposition, Jefferson, Hollydale, and portion of Lynwood Aquifer).	1000gpd/ft^2
Gravel with Clay Streaks	one-half of above values for gravel
Clay	0

ATTACHMENT 3

WELL NUMBERING SYSTEM AND DEFINITIONS

ATTACHMENT 3

TABLE OF CONTENTS

Well Numbering System

The well numbering system employed herein is that utilized by the United States Geological Survey, according to the township, range, and section subdivision of the Federal Land Survey. It conforms to that used in all ground water investigations by the U. S. Geological Survey in California and has been adopted by the Department of Water Resources.

Under the system, each section is divided into sixteen 40-acre plots, which are lettered as follows:

D	C	B	A
E	F	G	H
M	L	K	J
N	P	Q	R

Wells are numbered within each of these 40-acre plots according to the order in which they are located. For example, a well having the number 2S/11W-26B8 would be in Township 2 South, Range 11 West, Section 26, and would be further identified as the 8th well located in the 40-acre plot lettered B. Each well must be referenced to a particular Base and Meridian line, such as S. B. B. & M. for San Bernardino Base and Meridian (Southern California) or M. D. B. & M. for Mount Diablo Base and Meridian (Central California) and H. B. & M. for Humbolt Base and Meridian (Northern California).

Definitions

Anticline - Term applied to strata which dip in opposite directions from a common ridge or axis, like the roof of a house, and from what is termed an "anticline" or "saddleback" (Page D, Handbook of Geological Terms, London, 1859).

Aquiclude - A formation which, although porous and capable of absorbing water slowly, will not transmit it fast enough to furnish an appreciable supply for a well or spring. (Tolman, 1937, p. 557).

Aquifer - A geologic formation, group of formations, or part of a formation that transmits water in sufficient quantity to supply pumping wells or springs.

Confined Ground Water - A body of ground water overlain by material sufficiently impervious to sever free hydraulic connection with overlying ground water except at the intake. Confined water moves in conduits under pressure due to the difference in head between the intake and discharge areas of the confined water body. (Tolman, 1937, p. 558).

Connate Water - Water entrapped in the interstices of a sedimentary rock at the time it was deposited. (Tolman, 1937, p. 558). These waters may be fresh, brackish, or saline in character. Because of the dynamic geologic and hydrologic conditions in California this definition has been altered in practice to apply to water in older formations, even though in these the water may have been altered in quality since the rock was originally deposited.

Free Ground Water - Water in interconnected interstices in the zone of saturation down to the first impervious barrier, moving under the control of the water-table slope. (Tolman, 1937, p. 559).

Graben - Fault block bounded on both sides by gravity faults, generally long compared to its width, that has been lowered relative to the blocks on either side. (Billings, 1954, p. 203).

Horst - A block of the earth's crust, generally long compared to its width, bounded on both sides by gravity faults, that has been uplifted relative to the blocks on either side. (Billings, 1954, p. 203).

Impermeable - Impervious. Having a texture that does not permit water to move through it perceptibly under the head differences ordinarily found in subsurface water. (Meinzer, 1923, p. 20).

Isopach or Isopachous line - A line drawn on a map through points of equal thickness of a designated unit. (Glossary of Geology and Related Sciences, 1957).

Orogeny - The process of mountain building (Fay, 1920).

Perched Ground Water - Ground water occurring in a saturated zone separated from the main body of ground water by unsaturated rock (Tolman, 1937, p. 562).

Permeability - The permeability (or perviousness) of rock is its capacity for transmitting a fluid. Degree of permeability depends upon the size and shape of the pores, the size and shape of their interconnections, and the extent of the latter. (Glossary of Geology and Related Sciences, 1957, p. 217).

Permeability, field coefficient of - The amount of water moving through a unit area of aquifer per unit time under unit hydraulic gradient at the natural temperature. Ordinarily in gallons per day per square foot.

Permeability, coefficient of - Same as above, except that a reference temperature of 60 degrees Fahrenheit is defined. Other units are also used such as cubic feet per second per square foot, acre-feet per year per square foot, etc.

Permeable - Pervious. Having a texture that permits water to move through it perceptibly under the head differences ordinarily found in subsurface water. (Meinzer, 1923, p. 29).

Piedmont Slope - "When two or more streams flow out from a highland and closely adjacent to one another they may build a sloping plain, which is relatively high near the highland and lower further out, and which is composed of a series of fans in whose growth there has been mutual interference. This process produces a piedmont slope or series of coalescing fans." (Bryan, Kirk, U.S.G.S.W.S.P., p. 28, 1923).

Piezometric Surface - The piezometric surface of an aquifer is an imaginary surface that everywhere coincides with the head of water in the aquifer. (Meinzer, 1942).

Specific Yield - The ratio of the water a saturated sediment will yield by gravity drainage to the total volume of the sediment and water prior to draining, customarily expressed in percent.

Storage Coefficient - Volume of water released from storage in each verticle column of aquifer having a base one foot square when the water level declines one foot. In an unconfined aquifer it approximates specific yield. In a confined aquifer it is related to elasticity of the aquifer and is usually very small.

Syncline - A fold in rocks in which the strata dip inward from both sides toward the axis. (Glossary of Geology and Related Sciences, 1957).

Transmissibility, coefficient of - The rate of flow of water, in gallons a day, at the prevailing water temperature through each vertical strip, one foot wide, having a height equal to the thickness of the aquifer and under a unit hydraulic gradient. (Glossary of Geology and Related Sciences, 1957).

Unconformity - A surface of erosion or nondeposition, usually the former, that separates younger strata from older rocks. (Glossary of Geology and Related Sciences, 1957).